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Studies on the Hexactinellida.

CONTRIBUTION I.

(Euplectellidæ).

By

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With Plates I-XIV.

Introduction.

Having devoted a great part of my time for the last seven years to the study of the Hexactinellida, I at first conceived the idea of publishing all my results together in a single monograph, and to some extent preparations were made with that end in view. However, I have come to see that various unavoidable circumstances have combined to make unpleasantly dilatory the execution of that original plan. Let the work then appear in instalments as soon as the parts relating to this or that group of forms shall have been made ready for publication. I will begin in the present commu[illegible] with the eight species, representing three genera, of th[illegible] Euplectellidæ, which have been studied by me.

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If future circumstances should make it appear desirable, I may undertake in a separate memoir to give a synthetical representation of accumulated facts relating to, and the systematic of, the Hexactinellida in general, accompanied with as complete a list of relevant literature as I can bring together.

The appearance in 1887 of F. E. SCHULZE's 'Challenger' Report on the Hexactinellida—it need scarcely be said—has marked a new era in the history of our knowledge of this interesting group of the Spongida. In spite of the rich material described, the author at the close of that great work (p. 452) has given grounds to believe that only a relatively small percentage of the really existing Hexactinellid species was then known. Since that time, indeed, a considerable number of important additions to our knowledge of the group has from time to time been made, chiefly by the indefatigable zeal of that same distinguished investigator. The fact that this progress has been possible seems to give us still the promise that our present knowledge on the subject will yet be greatly extended and improved through further explorations and researches.

At the time that I took up the study of Hexactinellids, there were known in all from the Japanese seas 17 species (6 Lyssacina and 11 Dictyonina). These were as follows:

1. *Euplectella oweni* Marsh.
2. *Acanthascus cactus* F. E. Sch.
3. *Rhabdocalyptus mollis* F. E. Sch.
4. *Crateromorpha meyeri* Gray.
5. *Hyalonema sieboldi* ,,
6. ,, *affine* Marsh. (=*H. apertum* F. E. Sch.)
7. *Farrea occa* Carter.
8. ,, *vosmæri* F. E. Sch.

9. *Farrea sollasi* F. E. Sch.
10. *Periphragella clisæ* Marsh.
11. *Aphrocallistes bocagei* Wright.
12. „ *ramosus* F. E. Sch.
13. „ *vastus* „ „ „
14. *Chonelasma dœderleini* „ „ „
15. „ *calyx* „ „ „
16. *Hexactinella tubulosa* „ „ „
17. „ *ventilabrum* F. E. Sch.

With the exception of *Euplectella oweni*, which I believe is a native of southern Japan, all were from the Sagami Sea. That so many species have become known from this locality, is due to the labors of Dr. Döderlein, who long collected there.

I can not at present tell exactly to what extent the above number of species will be increased through my own investigations, since a portion of my Dictyonine materials yet remains to be worked over. However, taking the Lyssacina alone, I may say that from the Japanese coast thus far nearly 50 species belonging to that group have become known to me. Out of that number, no less than 44 are from the Sagami Sea,—a very considerable augmentation of the 5 formerly known Lyssacine species from the same locality (Nos. 2-6 of the above list). As regards the Dictyonina, I do not think the number of species can be increased in the same proportion, but I expect to be able to make several additions at least. And after all, I shall believe that I have made but a beginning in hauling up to light the rich Hexactinellid fauna of our neighboring seas.

The specimens which served as the basis of this work are for the greater part preserved in the Museum of the Zoölogical Institute of the Science College. An important contingent to

my material was also furnished by the splendid collection of Mr. Alan Owston, of Yokohama, which collection I understand has since been transferred to the British Museum. It was some of the beautiful specimens in his possession that instigated me in 1894 to the study of the Hexactinellida.

Here I beg leave to fulfil the pleasant duty of returning my grateful thanks to all those who have rendered me assistance in one way or another during the progress of my investigations.

The authorities of the Imperial University of Tōkyō, and the Publishing Committee of this Journal, have given me their most liberal support, the former in affording me all the material facilities needed and the latter in allowing *carte-blanche* the printing of my numerous plates.

Prof. F. E. Schulze of Berlin has favored me with much advice and information, which could not fail to be invaluable to me as coming from an authority of such profound experience in the same field of investigation.

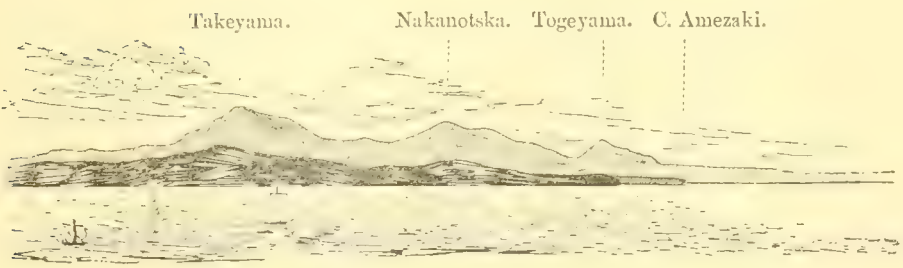
From Prof. K. Mitsukuri I have always received the attentive assistance of a most sympathetic colleague.

Mr. Alan Owston not only placed at my disposal the whole of his Hexactinellid collection already referred to, but also made a gracious gift of numerous valuable specimens to the Science College. I am under special obligations to him for the free use I was allowed to make of his gallant yacht, the 'Golden Hind,' on the many occasions of my collecting trips to the Sagami Sea.

In the execution of many of the drawings of spicules I have been ably helped at first by Mr. K. Nagahara and afterwards by Mr. Y. Nagasawa, assistants in the Zoölogical Institute. An

élève of mine, Mr. R. Uchida, has acquitted himself with great credit in the photographic work entrusted to him.

In the course of the text I will name other gentlemen in connection with the special matters, concerning which they have extended their help to me. But I should not forget to mention here the efficient service I have received from K. Aoki, collector of the Misaki Marine Laboratory,—better known as 'Kuma.' With praiseworthy enthusiasm and faithful subservience to orders, he has done the collecting for the Science College and for me, and it may be said that nearly all the numerous and interesting deep-sea things which now adorn the Museum of the Zoölogical Institute have been obtained by his efforts, or at any rate through his instrumentality.



View landward from off the south end of Miura Peninsula. Togeyama in line with Matswa Lighthouse.

Topography of the Sagami Sea.

(Pl. XIV.)

As before indicated, by far the greater number of the Hexactinellids to be described in the sequel are from the Sagami Sea; and since I have made it a point to state the locality of specimens as much in detail as possible, it seems desirable, for the sake of future reference, to give some notes on the topography of that sea, which, as the domain of work of the Misaki Marine Laboratory, is fast increasing in zoölogical interest.

The name, 'Sagami Sea,' is applied to that expanse of water on the Pacific side of middle Japan, which is partially circumscribed on the west, north and east by the coasts of the Provinces of Izu, Sagami and Awa respectively, and on the south by Oshima or Vries Island. The northern portion of the sea, so far as it is inclosed by the concave shore-line of the Province of Sagami, is known as Sagami Bay. On the eastern side the sea leads in a northerly direction into the Gulf of Tōkyō through the Uraga Channel. Between the latter and Sagami Bay juts out from the north the Peninsula of Miura, at the southern end of which lies the fishing town of Misaki. At about two kilometers' distance to the north of this town and on the west coast of the Peninsula, is situated the Marine Laboratory of the Imperial University of Tōkyō.

The Kuroshio, or Black Stream, sweeps up in a northeasterly direction outside of Vries Island, and under the southerly winds which prevail during the summer months, its waters, characterized by a deep blue color and crystal transparency, extend up into the Sagami Sea, sometimes as far as to Misaki.

On the chart (Pl. XIV), which I have prepared taking as basis the latest hydrographic charts published by the I. J. Navy,* I have put down the 10 to 500 fathom-lines along the coast as well as could be done. The 500 fathom-line is reached at a distance from the shore varying at different places from $4^1/_2$ to 20 kilometers. The deepest soundings recorded are from two isolated spots in Sagami Bay. The one, 908 fathoms deep and known to fishermen under the name of *Suribachi*, is situated only 5 kilometers to the south of the mouth of Banyū River. Just 10 kilometers farther south lies the other spot, 970 fathoms in depth and known as *Umanokura*. Both appear to be crater-like depressions surrounded on all sides by shallower waters.

To judge from what few soundings we have, the *Central Basin* of the Sagami Sea seems to present quite an uneven bottom, ranging from 400 to 700 fathoms and more in depth at different points. Between Izu and Vries Island, a narrow trough, one point in which gives a sounding of 810 fathoms, probably leads out uninterruptedly into the great ocean basin to the west of the submarine plateau on which the Seven Islands of Izu are situated. On the south-eastern side, the Central Basin seems to be separated from the *Gokeba Basin* (situated between Cape Mera and Vries Island, presumably sloping down outwards to the abyssal basin of Tuscarora) by a bottom much disturbed by submarine elevations that cause considerable shallowness of water in certain places. The most important of these is the submarine ridge known by the name of *Okinosé*, of which I shall soon speak again. The presence of comparatively shallow

* For a number of soundings on Okinosé and neighborhood, which do not stand in the published hydrographic charts but have been given in Pl. XIV, I am indebted to the courtesy of Rear-Admiral KIMOTSKI of the Hydrography, I. J. N., who kindly placed them at my disposal.

water in the space between this ridge and Vries Island is indicated by the soundings of 43 fathoms and 70 fathoms (see the Plate). The locality of the latter sounding seems to be separated from the northern slope of Vries Island by a submarine valley, which probably effects a communication between the deep trough along the Izu coast and the Gokeba Basin. The latter is assumably also connected with the central basin by a deep passage along the southern side of Okinosé. The headland of Mera in the Province of Awa extends itself in a southwesterly direction for some distance into the Gokeba basin as a submarine bank, called *Merasé* or *Onigasé* (the Devil's Bank), which is much dreaded by coasting mariners on account of the current from the Sagami Sea which at times sweeps out over it with furious velocity.

Okinosé is apparently a submarine extension of the promontory of Sunosaki, as Onigasé is of Cape Mera. It is known to stretch out westward for a distance of about 22 kilometers from Cape Sunosaki. The hydrographic charts contain a number of soundings on this spit, the shallowest sounding given being 37 fathoms. Its northern slope is known to the fishermen of Misaki as *Inside Okinosé* (Japanese : Okinosé uchibeta) and the southern, as *Outside Okinosé* (Jap.: Okinosé soto). The former dips down into a narrow trough leading from the Central Basin eastward in the direction of Tateyama Bay, to bend northward at a certain point and extend up the Uraga Channel as a shallower trough. The entrance into the above trough is considerably over 700 fathoms in depth as will be seen on the chart. Both slopes of Okinosé have proved to be very rich collecting grounds for zoölogists.

Before proceeding further in the orientation of our favorite collecting grounds, I should note the method by which the fishermen

of Misaki ascertain the position of their boats on the sea. This they do with wonderful precision, like all people of their calling on all coasts, by means of landmarks. I have often known them return to the spot where they had lost their fishing gear days before and successfully recover it from a depth of 300-400 *hiro*.*

For the sea immediately to the west and south of Misaki, an important landmark is furnished by a hill, called *Togeyama*, situated on the Miura Peninsula about $8^1/_2$ kilometers distant from its southern end. The hill in question is lower than two others in its proximity to the west, but is better adapted as an indicator, on account of its sharply pointed apex. (See the woodcut on p. 5). By bringing this apex to bear in a due straight line with other landmarks on the sea-board, the fishermen at sea distinguish a series of lines for the orienting purpose. Of these lines I have put down only the more important on Pl. XIV in blue. They are, beginning from the northernmost on the Sagami Bay side, as follows†:

1. *Togeyama* -o- *Kotō*.‡ (T. in line with a certain landmark on the shore of Kotō Bay).
2. *T.* -o- *Kōzuka*. (Kōzuka, the name of a mound near Nagai Village and distinguished by a tall pine-tree when seen from the sea).
3. *T.* -o- *Yahagi*. (A pine-forest in Yahagi Village, on the shore north of Shimomiyata).

* *Hiro* is a measure of length used by Japanese seamen for nautical purposes. It means the span-length of one's outstretched arms. However, the fishermen do not fully extend their arms in rapidly measuring the length of their lines and I have found by repeated experiments that their 1 *hiro* equals 4.7 feet (=1.43 meter) on the average.

† In the language of the Misaki fishermen, the different lines here mentioned are called 'Kotō-gaké,' 'Kōzuka-gaké,' 'Yahagi-gaké,' &c., 'gaké' meaning the act of bringing one thing upon another. The mention of Togeyama is altogether avoided as being understood.

‡ The symbol -o- stands for 'in line with.'

4. *T.* ⊖ *Kurozaki.* (Kurozaki, a cape at the entrance to Miyata Bay).
5. *T.* ⊖ *Kanda.* (Kanda-Yama, a pine-forest in the village of Mito.
6. *T.* ⊖ *Moroiso.* (The isolated, pine-covered hillock on the right side of the entrance to the Moroiso Creek, close to the Marine Laboratory).
7. *T.* ⊖ *Jōgashima Lighthouse.* (The lighthouse at the western end of Jōgashima, opposite Misaki).
8. *T.* ⊖ *Surushiki.* (Surushiki, a natural archway through a rock on the precipitous southern coast of Jōgashima).
9. *T.* ⊖ *Awazaki.* (Awazaki, a cape at the eastern end of Jōgashima).
10. *T.* ⊖ *Iwado.* (Iwado-Yama, a low hill near the southern end of the Miura Peninsula).
11. *T.* ⊖ *Sengenzuka.* (Sengenzuka, a mound-like islet near the coast with a group of pine-trees on its top).
12. *T.* ⊖ *Ena.* (Middle of the entrance into the little bay of Ena).
13. *T.* ⊖ *Matsiwa Lighthouse.* (The white-painted Lighthouse on Cape Tsurugizaki).
14. *T.* ⊖ *Amezaki.* (Cape Amezaki, the easternmost point at the southern end of the Miura Peninsula that can be brought in line with Togeyama).

For the sake of brevity the above lines may be called simply the Kotō-line, the Kōzuka-line, the Yahagi-line, and so forth.

In addition to the above series of lines, a number of other similar lines, determined by bringing the landmarks in the Province of Awa in relation either with one another or with

those in the southern part of the Miura Peninsula, are made use of, the two sets of lines serving as coordinates in fixing the position of a given spot. The summits of Nokogiriyama, Mineokayama and Tomisan ('Double Peak') and Cape Daibusa, are all useful landmarks on the Awa side, but the most important are furnished by Cape Mera and a range of adjoining hills, which successively heave in sight beyond the steep brow of Sunosaki as one sails outwards in a southerly or south-westerly direction from Misaki. (See the woodcut on p. 15). On Pl. XIV, I have inserted a few of the lines of this series, based on theodolitic observations which I myself have conducted at Sunosaki against the different sight-marks concerned on the promontory of Mera. Testing on several subsequent occasions has shown the approximate accuracy of the lines. They are:

1. '*Mera just out*;' i.e., the line on which the extreme head of C. Mera is just visible beyond the brow of C. Sunosaki.
2. '*Mera* 1' (Jap.: *Mera hitots*); i.e., the line on which the first hill of Mera is completely in sight or the first notch of the Mera ridge is in line with C. Sunosaki.
3. '*Mera* 2' (Jap.: *Mera futats*); i.e., the second hill completely in sight.
4. '*Mera* 3' (Jap.: *Mera mits*); i.e., the third hill completely out. (See the woodcut on p. 15).
5. *Mochiyama* ⊖ C. Sunosaki. For the former, a conspicuous tree on the sky-line of the Mera hills serves for a landmark.
6. *Otaka* ⊖ C. Sunosaki. The former should be a locality farther inland than Mochiyama.

As in the case of the lines that center at Togeyama, so also in the present series the fishermen are wont to distinguish by name a greater number of lines than I have given. For instance, they speak of '*Mera kandai-kobu*,' by which is meant the positions whence as much of the Mera headland as in shape resembles the hump-like protuberance (Jap.: *kobu*) on the snout of a Labrid fish, *Chœrops japonicus* (Jap.: *Kandai*), is seen to project beyond Sunosaki; of '*Mera* $^1/_2$,' when only one half of the first hill of Mera is visible in a similar way; of '*Mera* $1^1/_2$,' '*Mera* $2^1/_2$,' etc.

Referring to the blue lines on Pl. XIV, it will now be clear what points on the Sagami Sea are meant by such expressions as, '*Kotō-line* and *Mera just out*,' '*Kōzuka-line* by *Mera* 1,' '*Yahagi-line* by *Mochiyama*,' '*Outside Okinosé*' by *Iwado-line*,' &c.

There still remain to be mentioned a few more names of localities where the Misaki fishermen do most of their deep-sea fishing (chiefly for *Bathythrissa dorsalis*) and which have yielded us rich supplies of zoölogical specimens.

By the name of *Yodomi* (meaning 'the stagnant water') is known the region of 400-500 fathom-lines, 11-18 kilometers westward of Misaki. It is divided into Nishi-no-Yodomi, Naka-no-Yodomi and Maye-no-Yodomi.

Nishi-no-Yodomi, or the 'Western Yodomi,' is on the *Kotō-line*, the other bearings being Tomisan ⊖ Moroiso and Enoshima NNE.

Naka-no-Yodomi, or the 'Middle Yodomi,' lies on the *Kōzuka-line* by nearly *Mera* $^1/_2$.'

Maye-no-Yodomi or the 'Front Yodomi,' so called on account of its being the nearest Yodomi to Misaki, is situated on

the *Yahagi-line* by *Mera* 1½—2. A short distance ENE of this ground is a place called *Haidashi*, about 120 fathoms deep, where the fishing for *Sepia* and also for *Seriola quinqueradiata* is extensively done at certain seasons of the year.

Mochiyama is a long-lining ground on the northern side of the deep trough leading towards the Uraga Channel. It lies nearly on the *Surushiki-line* and derives its name from being on the line of the same name in the Mera-Sunosaki series.

Numa, or the 'Marsh,' so named on account of the soft muddy bottom, is reached by steering on the *Matswa-Lighthouse-line* and by bringing Cape Daibusa to bear nearly due east. Cape Mera still lies out of sight behind Sunosaki. On the chart, the locality falls nearly on the spot where the deep trough on the north of Okinosé divides into two gullies, the one directed towards Tateyama Bay and the other leading into the Uraga Channel.

A short distance farther south than Numa is situated *Dō-ketsba*, or the 'Euplectella-ground,' a name given by myself in 1894 and which has since been in use among the collectors. I think this ground constitutes a portion of the northern slope of Okinosé at a distance of 4-10 kilometers to the northwest of C. Sunosaki. So far as I can state at present, it comprises the area between the *Ena* and the *Amezaki* lines on the one hand and between the lines '*Mera* 1' and '*Mera* 3' on the other. The depth varies from 75 to 160 fathoms and over. The bottom, exceedingly rich in varied forms of life, is shelly.

In the broad sea south of Okinosé are situated two more important fishing grounds, Homba and Gokeba. From the latter I have called that entire region the Gokeba Basin.

Homba is situated a little over 10 kilometers SW. of C.

Sunosaki,—nearly on the *Ena-line* and Toshima (a pyramidal islet forming one of the Seven Island of Izu) just heaving in sight at the southern end of Vries Island. As seen on the chart, it apparently lies on the southward continuation of the slope of Outside Okinosé. According to KUMA's statements the water at this place is 300 *hiro* (235 fms.) and over in depth and should abound especially with *Apistus matsubaræ* Hilgd. (Jap.: *Akō*) among the marketable fishes.

Not far distant to the south of Homba is situated *Gokeba*, or the 'Widow's Place,' so called in allusion to erstwhile disasters to fishing crews that made so many widows. The place should be 15 or 16 kilometers away from C. Sunosaki and the depth 400 *hiro* (313 fms.) and over. The landmarks on the Miura Peninsula are here no longer of use, and the fishermen find the place by the bearings: Tomisan ⊖ C. Sunosaki and Takatsukayama ⊖ C. Mera.

Geologically speaking, the bed of the Sagami Sea seems to consist for the most part of volcanic rocks as well as of clays, sandstones, breccias, &c. of a tufaceous nature, such as we find exposed on the surrounding land,—a fact which is borne out by samples of the bottom picked up at various points.

In faunal respects, the extraordinary richness of the Sagami Sea in new forms will in the near future be more than ever convincingly laid before the scientific world with the publication of the works now being carried on by several naturalists in Japan. The interesting occurrence of forms, generally considered to belong to abyssal depths, within easy reach from the shore and in relatively shallow waters of 100-400 fms.,—a fact which

is to be explained by the comparatively steep incline of the bottom and the proximity of much greater depths,—offers exceptional facility to those who wish to study them. And to this circumstance must be ascribed in great measure whatever success I have had in collecting my Hexactinellidan material.

View of Cape Sunosaki with the Mera hills in the background. Seen from a point on the line 'Mera 3.'

Collecting Hexactinellida and other Deep-sea Animals in the Sagami Sea.

In an article entitled 'Long-Lines as Zoölogical Collecting Apparatus,' published in the Zoölogical Magazine ('96*a*), I have dwelt at length upon the character and extent of the work which can be accomplished in the collecting of specimens from a considerable depth by the sort of fishing gear known in general as the long-line. It is the tackle by means of which nearly all the innumerable Hexactinellid specimens hitherto obtained in the Sagami Sea have been collected—from probably the very first 'glass-ropes' described nearly seventy years ago by GRAY as *Hyalonema*, to the numerous superb specimens now to be seen in the British Museum or in the Science College Museum; and since my above-mentioned paper is likely to be not easily accessible to many, I may be allowed to go once again over the same matter.

There are used in the Sagami Sea two sorts of long-lines (Jap.: *Hainawa*, i.e., the trailing-line), *viz.*, the mackerel-line and the dabo-line, both of which are adaptations of the form of long-lines in general. The tackling of the mackerel-line, employed for small depths only, is too weak to be of much use for our special purpose. The dabo-line, primarily intended for angling at a depth of 300-400 *hiro* or over for *Bathythrissa dorsalis* GTHR. (Jap.: *Dabo-gisu*, whence the name of the line), is the sort that we have used with much success in our zoölogical collecting.

The dabo-line consists of a main-line of about the thickness of a quill and of numerous thinner branch-lines, called

snoods, each of which terminates in a simple hook. The snood is a hempen string about $1^1/_2$ mm. thick and about 1 *hiro* long, fixed to the main-line at intervals of the same length. The hook is made of brass or iron wire, $1^1/_2$ mm. thick and 45 mm. long in the unbent state. Its point is barbed and slightly bent inwards in order to prevent its catching the hard bottom too frequently and thus becoming straightened out by the pull. When in store, the dabo-line is coiled up in shallow baskets, each containing normally 100 *hiro* of the main-line with about an equal number of the snoods and hooks. The hooks are stuck to the basket-edge in a serial row, so that when the main-line is being paid out they are detached and given off in succession from one end to the other of the row. Ten to twenty basketfuls are used at a time, the main-lines being tied end to end.

The boat for dabo-lining is manned by at least five men. On the way to the fishing ground, generally under sail, the baiting of the hooks is accomplished with expedition. For the bait is employed any kind of cheaply or conveniently obtainable fish, cut into suitable sizes. Arrived at the fishing ground, a strong rope, thicker than the main-line in the baskets, and of a length somewhat greater than the depth at the spot, is paid out. This rope is intended to descend perpendicularly to the bottom. Its upper end is buoyed, generally by means of a closed tub to which is fixed a wand with a bunch of bamboo-branches at the top,—a broom-like arrangement which is kept erect by the weight of the perpendicular rope below and serves as a sight-mark from distances. To the lower end of the rope is attached a stone as a sinker and here is also tied one end of the dabo-line in the basket. As the sinker descends and the boat is slowly rowed away, the dabo-line runs out of itself, while one

of the hands superintends the picking up of the baited hooks that are thrown out one by one in succession. When the first basket is emptied, the main-line is tied to that of the next, and so on, until the intended number of baskets are empty. During the above process, stone-sinkers are fastened here and there to the lines, being for the most part simply slung in loops of strings so as to fall off the instant they strike the bottom and thus avoid increasing the difficulty of hauling in the lines. The laying out is finished by giving off a second perpendicular rope, which, like the first, carries a buoy at its upper end.

After from half an hour to an hour, the hauling in of the lines begins at the end marked by the first buoy. If by accident the cordage breaks during the hauling in, the other buoy is sought and the process is renewed in the opposite direction. The same bad luck may again occur, leaving perhaps hundreds of meters of the dabo-line helpless on the bottom. On one such occasion in my own experience, I had to give up fifteen basketfuls at once. My boat was at the time being overtaken by an unpleasant squall, and, to say the truth, I felt much relieved by the misfortune, for it had become decidedly uncomfortable to prolong our stay on the angry waves. If the familiar landmarks be visible, the fishermen know the exact place where their lost line is lying, and if it be of a length worth the trouble, attempts are made to recover it and generally with success. Either a certain amount of the dabo-line on hand is dragged over the lost section for that special purpose or dabo-lining is started afresh, laying out the new line so as to trail across the lost one, thus combining the process of rescue with the routine work of fishing. Even in the latter case, the line on the bottom is subjected to a considerable dragging movement as the result

of the pull in hauling in, so that there undeniably exists no small chance for some of the numerous hooks to get hold of the lost line, as well as of the objects lying passively on the bottom over which it passes.

Under certain circumstances, the dabo-line is laid out in a circle or at any rate in such a way as to bring the two ends near to each other. When so laid, the line can be hauled in from both ends at once by the same boat, thus saving much time. This method is therefore resorted to late in the afternoon or when there is a prospect of unfavorable weather.

Still another way of fishing with the dabo-line requires to be specially mentioned. One of the crew handles the sweep, while each of the others lets out, not all at the same time but in succession one after another so as to avoid entangling, only about a single basketful of the dabo-line with the requisite number of sinkers. A greater length of the line would prove too heavy for one man to manage. One end of each of these lines is free, while to the other is attached a hand-line of suitable length. After the last man has paid out his line, the boat is still rowed on for some time, so that the several trailing dabo-lines, each handled by a man on board, are slowly pulled along the bottom. There is one obvious advantage in this system inasmuch as it involves but little risk of losing any extensive amount of the line at any one time.

When the dabo-line is to be hauled in, a thick bamboo is rigged alongside the boat. Over its smooth surface the cordage slides as the latter is tugged in. The process involves from three to four hours of hard and incessant work for three men, with two others in reserve to change hands. The introduction of a suitably constructed windlass would materially lighten this labor.

As it is, I should think that fishing twice at a depth of 300-400 fathoms, each time using a dozen basketfuls of the dabo-line, should be considered a very good day's work. As is easily imaginable, a rocky bottom offers the greatest obstacles to this method of fishing. The hauling in is scarcely ever accomplished without the line sticking repeatedly to the bottom, to be unfastened only by persevering efforts. As the line is being pulled up, it is coiled in the baskets, while the hooks are replaced in a row on the basket edge as before.

Having been myself on numerous occassions aboard a dabo-liner, captained by KUMA, I am in a position to point out critically the various ways in which the dabo-line brings up objects from the sea-bottom. These are either caught upon the points of the hooks or entangled in the cordage. Again, hooking takes place in two ways. Firstly, the bait allures the animals to take the hook. All the fishes and some isolated cases of lower animals come under this category. Secondly, the animals are hooked passively, as it were, irrespective of the bait. This process, together with entangling presently to be described, plays the most important rôle in bringing up zoölogical specimens other than fishes and certain lower animals of voracious habits. Even objects of quite insignificant size, such as sea-urchins of the size of peas or beans or Euplectellæ of no greater thickness than a goose-quill, are known to have come up sticking to the points of the hooks. It would seem that many of the things thus picked up by the hooks were present in great abundance on the bottom. Even then, with a small number of hooks the chances of their fastening on these in a proper manner can be anything but great. Should however hundreds of hooks be employed, as in the case of the long-lines, the matter is

somewhat changed, especially if they be kept in motion while on the bottom. I have already called attention to the fact that the trailing line and with it the hooks are more or less pulled along the bottom during the process of hauling in, even though no attempt at dragging be purposely made. Moreover, I think I am justified in assuming that the fish caught by the hooks and striving to escape at the ends of the snoods, set the cordage in motion and thereby play a significant part in bringing the unoccupied hooks against the bottom-objects. The dragging, when intentionally resorted to, must be carried on very slowly but not necessarily for a prolonged period of time; for, there exists as much chance of damaging or losing specimens once caught by the hooks, as of gaining by long continued dragging. It would seem that the increase of hooks beyond the usual number, or the use of double, treble or quadruple hooks should substantially add to the efficiency of the long-line as a collecting apparatus. In practice, however, I have found little or no difference. What might thereby be gained seemed to be annulled by the necessity of extra caution in handling the lines on account of the increased number of the points of the hooks, which are so liable through accident or a slight mismanagement to inflict painful wounds on the persons of those absorbed in the strenuous labor of hauling in.

Not less important than hooking is the process of entangling. All the large or heavy objects (such as corals and rocks with various animals growing on them, &c.) could not possibly have been obtained, had not the snoods, the main-line, or both together coiled around them. In lowering the lines, it is exceedingly likely that portions of them should reach the bottom in confused coils and loops, which are tightened on being pulled, and

thus effectually ensnare the bodies upon which they have happened to fall. Furthermore, a very frequent cause of objects becoming entangled in the snoods seems to be the struggles of the fish that have been hooked. As a matter of fact, I have often observed some valuable specimen come up tied on to a snood at the end of which was a fish. On this account, KUMA is in the habit of baiting the hooks even though he be bent on capturing such an unvoracious animal as the sponge.

It is needless to say that the quantity of the catches is a matter of luck, as much, I think, as when a trawl or a dredge or a tangle is used. As often as not meters upon meters of the line are hauled in without any sign of the baits having been touched, indicating that that portion of the line did not reach the bottom at all, or with indications of scraping against rocks, the hooks carrying nothing and some of them being perhaps straightened out. But then, there may follow a long section in which almost every other snood has something on it.

It would lead me too far if I were to give an adequate description of the mass and variety of animal forms that have been obtained during the last seven years in the Sagami Sea by means of the dabo-line, both as it has been used persistently and systematically by ourselves, and also by the fisherfolk who with it gain by-profit to their proper earnings. So far as the Hexactinellida is concerned, an idea of what can be achieved with this fishing gear will be duely gathered in the course of this and following contributions. As to the other animals obtained, let it suffice to give here the barest sketch.

As before mentioned, the dabo-line is primarily intended for use in fishing for *Bathythrissa dorsalis*. At the same time the other fishes caught by it are varied and numerous. In

certain localities a species of *Bdellostoma* can be obtained in scores. It is a great nuisance in the fishing not only on account of its glutinous slime but also because it swallows the hook so deeply that the snood has to be cut away in removing the fish. *Chimæra* and *Cestracion* are not seldom brought up; and of other sharks, representatives of the genera *Pristiurus*, *Spinax*, &c. are often captured in quantities. The Muræniдæ is commonly represented by two or more species. The rest of the Teleostians are mostly the large-eyed and blackish or bright red forms, characteristic of the deep-sea fauna. As the more commonly caught of these I may mention *Scombrops*, *Hoplopholyrus*, *Thyrsites*, *Sebastes*, *Apistes*, *Beryx*, *Polynemus*, *Macrurus*, &c., many of these genera being represented by several species. It is by no means unusual that some half a dozen, sometimes as many as ten or more, different species of fishes are secured at one haul. Not that certain fixed species alone take the bait, but also now and then forms are hooked up that are totally new to experienced long-liners and fitted to throw an ichthyologist into ecstasy.

Next in abundance to fishes come the passively caught sponges and Coelenterates. Of the former, the Monaxonids and Tetractinellids are, like the Hexactinellida, quite rich both in species and individuals, some of these coming up in certain localities even in vexatiously profuse quantities. That such a tiny form as the pea-sized *Stylocordyla* can be hooked up may seem incredible but is really the fact. The Calcarea have been occasionally brought up, mostly attached to some other objects. Horny sponges have never yet been found in the Sagami Sea at any depth.

Among the innumerable Hexactinellids hitherto obtained by means of the dabo-line there are some which I can not pass over

without mentioning on account of their imposing dimensions or of the remarkable circumstances under which they were captured. A specimen of *Hyalonema sieboldi* in the Science College Museum, superbly preserved except for a rent which was probably made by the hook or the snood, has a body 250 mm. long and 210 mm. broad ; this is probably the largest specimen of the species ever obtained. Of the many specimens of *Euplectella imperialis* in the same Museum, one in particular is distinguished by its stately size, having a total length of 825 mm. and a diameter of 137 mm. at the top. With respect to *Euplectella marshalli*, I have been so fortunate as to discover a locality (Dōketsba) where the dabo-line has never failed to supply me with fresh specimens whenever these were wanted. On this ground I have also used with success an arrangement similar to the well-known apparatus used in the Philippines for the capture of *E. aspergillum*, viz., a bamboo-rod furnished with hooks, which is dragged along the bottom.

One of the commonest glass-sponges in the Sagami Sea seems to be *Acanthascus cactus* F.E.Sch., specimens of which were at first very highly prized by us but later began to be brought by the dabo-lining fishermen in such large quantities that we had to cease offering any price for them, as we had done long before with Hyalonemas, unless the specimens were of exceptional beauty. Among the numerous exquisitely preserved specimens which I have seen of *Rhabdocalyptus victor* Ij., the most magnificient one is in the Sci. Coll. Museum. It measures 2 feet $10^1/_2$ inches in length and 10.6 inches in breadth at the middle. It is nearly perfect in all its parts except that it is sewn together right around the middle of the body ; for, at the moment it was heaved out of the sea, after coming up coiled in

the dabo-line from a depth of 600 *hiro*, its own weight upon the rope cut the body into two. One half of this grand prize was securely entangled but the other half went sinking down and would have been lost forever, had not KUMA pluckily dived and secured it just in time.

A gigantic specimen of *Aphrocallistes vastus* F. E. SCH., purchased by Mr. OWSTON of a fisherman and which doubtless is now in the British Museum, measured about 22 inches in height and 20 inches across at the widest part. It could have been obtained only by the rope of the long-line.

A dead but a very striking specimen of *Chonelasma calyx* F.E.SCH., in the possession of the Sci. Coll. Museum, deserves to be specially mentioned on account of the host of animals that are attached to it (see the halftone figure on p. 31). For, it bears no less than: 1 small *Rhabdocalyptus glaber* IJ.; 6 young *Rhabdocalyptus capillatus* IJ.; 5 small *Chaunoplectella cavernosa* IJ.; 1 small, dead and undeterminable Dictyonine Hexactinellid; several *Thenea* sp.; 4 calcareous sponges representing 2 species; 1 Lithistid; several Monaxonid sponges; over 70 (!) *Terebratella blanfordi*; 9 *Laqueus rubellus*; several *Lima* sp.; 1 *Fusus* sp.; and finally a goodly number of Ophiurons and Bryozoans! Another similarly interesting object is a large barrel-like *Hexactinella*, which frequently bears on it among other things a number of smaller glass-sponges. These cases will sufficiently illustrate with what delight we have welcomed everything—including stones and rock-fragments (often several pounds in weight), coal-cinders which must have been thrown overboard from steamers, and even old tin-cans and such like things—that the long-line has brought up from the bottom.

After what I have said above with respect to sponges, I

think the reader can form for himself a fair idea of what and to what extent deep-sea Cœlenterates may be collected by means of the lines we have used. I will only add that a very valuable and extensive collection of Hydroid colonies, Antipathidæ, Alcyonidæ, Gorgonidæ and Pennatulidæ has been accumulated in the Sci. Coll. Museum, since we have taken to dabo-lining. The colonies of *Cladocora* and of similar stone-corals have often been a source of delight on account of the animals found among their branches. Even small members of the Fungidæ were now and then picked up by the hooks.

Of the Echinoderms, the Ophiurons rank first as those most frequently caught by the dabo-line. The starfishes, Echini and Holothurians—among them some very rare forms—are fairly well represented. Such a little thing as *Pourtalesia* was once obtained, half a dozen together, at one haul of the line. *Metacrinus rotundus* is one of those animals whose value as specimens has greatly fallen in our estimation, since we have learned the comparative ease with which it can be obtained. It is well-known to Misaki fishermen under the name of 'Bird's leg.' I have frequently taken it together with *Euplectella marshalli*, &c., with the dabo-line from a depth of 100 fathoms or less.

The Crustaceans consist mostly of brachyurous and macrurous Decapods of all sizes, and often of the most extraordinary shapes. As for the famous giant-crab, *Macrocheirus kæmpferi*, I think the dabo-line is the only apparatus that brings it up from its native haunts. Off Odawara I have myself captured three or four specimens. They all came up simply entangled in coils of the dabo-line and were helpless creatures, scarcely able to move their limbs when taken on board, although they are believed to be rapacious animals when in their native depths and are much

dreaded by the fishermen who often attribute the severing of the line by a clean cut to the work of their powerful pincers. The carapace of the giant crab not infrequently bears upon it a variety of other animals. Once I obtained therefrom some valuable specimens of Rossellids, of Hydrozoa and of a small stalked Crinoid, besides a number of *Lepas*, &c.

The Tunicates, both simple and compound, as well as the Brachiopods are also tolerably well represented among the trophies of the dabo-line. The worms and molluscs seem to be the most difficult for the dabo-line to catch hold of. Nevertheless, I have seen *Aphrodites* and Nemerteans hooked up, not to mention the cases in which such animals have been brought up attached to other objects. Of the molluscs obtained by the hooks of the dabo-line, I may mention two or three remarkable cases. *Opisthoteuthis depressa* Ij. & Ik. is a very rare and anomalously shaped species of Octopod, which I described in 1895 (this Journal, vol. VIII), conjointly with Mr. S. Ikeda, from the single specimen then existent. It was captured by the dabo-line, having swallowed a hook baited with shark-flesh. Early last year I was rejoiced to receive from Kuma a second specimen of this most remarkable Octopod, much finer than the first. It was captured in a similar manner. *Amphitretus pelagicus* Hoyle is another very interesting Cephalopod, upon which Hoyle (Chall. Rep., vol. XVI) bases a distinct family and which has hitherto been known in an unique specimen obtained by the 'Challenger.' In 1897 a second specimen of the species fell into our hands; it was likewise secured by Kuma, having taken a baited hook of the dabo-line. The Gasteropod genus *Pleurotomaria*, of which living specimens are extremely rare and held by dealers at an enormous price, is represented in the Sagami Sea by *Pl. beyrichi*.

Mr. Owston had made persevering efforts, long in vain, to secure a specimen of this Gasteropod and had caused circulars, containing pictures of it and offers of tempting rewards, to be widely distributed among the fishermen in general. One day in 1894, Kuma again incidentally angled a large and beautiful snail, which he thought might prove to be the one that the Yokohama naturalist and no less the Sci. Coll. Museum were in want of. It had swallowed the dabo-line hook baited with cuttle-fish. He brought it to us and returned home very handsomely renumerated for his trouble. Thenceforth *Pleurotomaria beyrichi*, till then without a Japanese name, began to go among the Misaki dabo-liners under the title of 'Chōja-gai,' or the 'Millionaire Shell.' Mr. Owston now knew precisely the particular kind of fishermen to whom he could direct his circulars with some probability of success. He acted accordingly and the result was that ere long he became the happy possessor of several 'Millionaire Shells.'

I think I have said enough to show that the dabo-line—in fact all the so-called long-lines, provided they are sufficiently strong but not unwieldy—can be of immense service to zoölogists. The fact that a number of valuable specimens had been obtained incidentally by a similar kind of fishing arrangement in other parts of the world has long stood on the records. For instance we learn from Barboza du Bocage ('65 & '70) and Percival Wright ('68) that the first Hexactinellids that became known from the Portuguese coast (*Hyalonema lusitanicum*, *Pheronema carpenteri*) were taken by fishermen while shark-fishing by means of a rope in length some 600 fathoms, 30 or 40 fathoms of which had fastened to it a series of snoods and baited hooks. When the Portuguese fishermen bring up *Hyalonema*, as they

seem not infrequently to do, it is regarded as a bad presage and the objects are directly thrown back into sea. Exactly so with the fishermen of the Sagami Sea. Many indeed must be the objects brought daily to the surface by the numerous dabo-liners during their season,—objects perhaps of great value to naturalists but which to their eyes are all unwelcome 'filths,' 'weeds' or 'useless cottons.' From sheer habit or perhaps from wrath or even for the sake of precaution against receiving stings, the fishermen manage to get rid of them as soon as practicable, often without once heaving them out of the water. However, by giving them ample encouragement for a continuous period, which meant a not inconsiderable outlay, we succeeded in bringing many to appreciate that their 'filths' might possibly be found to contain gold when shown to the proper connoisseurs on land. Wherever the same or similar methods of fishing are carried on and there is a fair prospect of success, naturalist collectors would do well to do their utmost to 'educate' the fishermen for their own benefit.

It goes without saying that long-lining, like any other method of deep-sea collecting in common vogue, has its advantages and disadvantages depending upon the character of the depths, of the bottom, of the animals to be collected, &c. The process recommends itself as being relatively simple and inexpensive, enabling us to reach a tolerably great depth where dredging or trawling can only be managed by steam-power or, if the bottom be rocky, is scarcely possible at all. In the case of certain animals—the Hexactinellida to wit—the long-lines as a collecting apparatus seem to be at least as effective as the trawl, and in a certain sense they are decidedly more effective. When the 'Challenger' was at work in Sagami Bay, what her large trawls and dredges

failed to secure, was obtained in abundance by the hooks of the native fishermen, who then happened to be engaged in their business near her. Says Willemoes-Suhm ('76) in one of his 'Challenger' letters: "It was very fortunate for us to have met with these boats (the Sagami fishermen's), for, were it not for them, we would perhaps never have known that we were on the *Hyalonema*-ground." This single instance may have no real significance, but at any rate, the chance for even the largest trawl to bring up such numerous large Hexactinellid specimens in as clean and perfect a condition as those obtained by the long-lines, must be said to be very poor indeed. The Hexactinellid materials, which were dredged chiefly by Pourtales and Al. Agassiz and worked over by O. Schmidt ('70, '80), were apparently nearly all incomplete or otherwise unsatisfactory specimens, many being in no better state of preservation than fossil remains. Of the numerous Hexactinellid specimens collected by the 'Challenger' chiefly by means of trawls and dredges, only a few were quite perfect, all the rest having been injured in one way or other (Schulze '85, p. 437). I think the same may be said in general of the trophies of the 'Investigator' and of the 'Albatross,' so carefully described by the masterly hand of F. E. Schulze. When the latter ship was in Japan in the spring of last year, I was allowed, by the kind courtesy of Captain Moser, to stay on board during her collecting cruise over my old grounds. She made, generally speaking, very successful hauls with her 'Tanner' and 'Blake' trawls, but what greatly impressed me was the comparative scarcity of the Hexactinellida among the catches and the fact that what was obtained of that group of sponges was mostly in fragments, badly macerated and soiled. There was a time when I myself tried trawling

for *Euplectella* at Dōketsba, but I have long since abandoned that method in favor of long-lining; for, the specimens obtained by the trawl were always in a sorely mutilated condition, caused partly by the manner in which they were rooted out but more especially by their having been dragged along in the bag with so many other things.

After all my experiences I believe that the long-line ought to be classed, together with the trawls, dredges and tangles, among the most important of a deep-sea collector's equipments. As to modifications that can likely be effected in the method, the better to suit the requirements of its new sphere of application, a series of ideas should suggest themselves to all who give a thought to the matter. The introduction of mechanical contrivances for hauling in the lines; the addition of hempen swabs to the main-line; combination with dredge or trawl; special designs after the principle of the long-line; &c.,—these are some of the points that seem worth recommending to the consideration of future deep-sea explorers.

Dead *Chonelasma calyx* bearing a host of other animals. $^1/_3$ nat. size.

Methods used in the Studies.

Unless intended for histological investigations, specimens were simply thrown into alcohol—which was changed after a while—and then permanently preserved in 70% alcohol, as far as was practicable. Such specimens also gave the best results when afterwards dried. Those which seemed not worth putting into alcohol or could not be so prepared, were soaked in plenty of fresh-water for several hours or overnight, during which interval the water was changed now and then; they were then dried as quickly as possible. When imperfectly 'desalted,' dried specimens are apt to absorb moisture and become soft and dirty after a time; in such cases the proper firmness may be restored by again immersing in fresh-water and desiccating as before.

For the study of spiculation it was found quite important in the first place to make preparations of the dermal and the gastral layer and of a piece of the parenchymal septum, all to be removed in such a way as not to disturb in the least the relative position of individual spicules. The pieces may conveniently be mounted in Canada-balsam under the same cover-glass. For a detailed study sections of the body-wall, better unstained than stained and cut from a piece imbedded in paraffine, were invaluable. Certain points in the spiculation can only be determined in this way.

The spicules may be cleaned of the crusts of soft parts by boiling in sulphuric or hydrochloric acid. They are then to be examined in water or after mounting in Canada-balsam. The axial cross and filaments in even the finest hexasters are

made most plainly observable when the spicule is inclosed in glycerine, in dammar, in the acid in which it was boiled, or in fact in any medium whose refractive index equals or nearly equals that of the siliceous matter.

For the histological study of soft parts I have tried, whenever opportunities offered themselves, to preserve samples of the various Hexactinellids in special ways. Since *Euplectella marshalli* was the most readily accessible species, my experiments with different reagents and my subsequent study of the soft tissues were mainly conducted on that species.

Right at the spot of capture and as soon as the sponge came up to the surface, it was received directly into a bucket while still in the sea. It was then immediately cut up into small pieces, which were thrown at once into the several reagents. The latter were contained in tubes or bottles supplied with an elevated false bottom in order to facilitate the rapid replacement of the sea-water by the killing fluid. I have used utmost despatch in these processes to make sure of the reliability of the results. However, certain experiences have led me to think that with proper precautions—i. e., by keeping them in the dark, cool, quiet, and in a plenty of good sea-water,—the soft tissues remain for some hours in about the same condition, though not in as active a state of life, as when first brought up from the sea-bottom. Hence, opportunity is given us of examining comparatively fresh tissues in the laboratory.

With fresh objects thus brought home I have repeatedly tried silver (HARMER's method) and Methylenblau (MAYER's method) impregnation; but never once have I been able to bring out cell-outlines either on the trabeculæ or on the chamber-wall.

For killing and fixing the soft tissues, trials were made with a large number of reagents, such as absolute alcohol, concentrated solutions of corrosive sublimate (used cold or hot and with or without the addition of a little glacial acetic acid), PERENYI's fluid, FLEMMING's weak solution, HERMANN's fluid, $^1/_{20}$-$^1/_{10}$% osmic acid, &c. Of all these, corrosive sublimate dissolved in sea-water gave me fairly constantly the best results. All the rest were rather uncertain as to the outcome. I have also tried, for the sake of comparing the results, such slow working reagents as chromic acid and picrosulphuric acid from which no good outcome could be anticipated, and have even sectionized samples which were purposely macerated by leaving them in water.

One of the advantages of using corrosive sublimate dissolved in sea-water is the simplicity of the method, which is an item of great importance when one has to work in a small open boat as I have had to do. I used to prepare the solution on the way to the collecting ground by simply adding the sublimate to a small bottle of sea-water in a quantity somewhat greater than could be dissolved. The bottle was shaken now and then during the few hours I had still to wait. Pieces of the sponge, each in size not more than 15 mm. square, were thrown into the fluid and left there for about half an hour, sometimes longer. They were then washed in distilled water, using a pair of bamboo chopsticks for picking them up. During the return journey, they usually remained in a plenty of distilled water in a large bottle, which was once in a while carefully moved so as to set the objects swimming. Reaching shore, the objects were put into 70% alcohol, which was changed in an hour or so. After at least 24 hours, they were transferred into 90% alcohol, to be replaced with absolute alcohol in another day or two. In

changing the fluids care is necessary never to allow these to drain off from the cavities of the object. The inclusion of air-bubbles can be prevented by effecting the transference slowly until the new fluid covers the object.

Specimens fixed in the above way can be most readily stained, for which purpose I have extensively used GRENACHER'S borax-carmine and KLEINENBERG'S or DELAFIELD'S hæmatoxylin in preference to either alum-carmine or picrocarmine. Beautiful as were the hæmatoxylin preparations, these seemed to show no particular merit over the results attained by the borax-carmine, and the latter has been more commonly employed for general purposes as giving more durable and more uniformly successful results. As a weakness of all the staining fluids above referred to, it may be mentioned that they do not always color the protoplasm of the tissues with desirable intensity. I felt this shortcoming especially in clearly making out the structure of the chamber-wall. In such cases, however, good results were achieved by staining once again, after laying out into sections, with a so-called plasma stain (f. i., acid-fuchsin). Even in the case where staining after cutting is preferred, I have often found it advisable to give a faint coloring to the object before imbedding; for, colorless pieces of the sponge become almost invisible in the paraffine, making the orientation of parts difficult or impossible.

For imbedding I have gone through the usual steps. Removing the alcohol with turpentine gave just as good results as when the elaborate method of gradual replacement by the use of chloroform was resorted to. The final imbedding took place in pure hard paraffine of 60° C. melting point.

In spite of the siliceous spicules very thin sections can be

cut. Practically for the histological purpose the sections need not be thinner than 10 μ, since the tissues themselves are everywhere exceedingly thin. On the other hand, sections as thick as 50 μ and even up to 100 μ or more were found of great use in the elucidation of the general structure. Except for anatomical purposes, an uninterrupted series of sections are of no benefit.

Sections were fixed on the object-glass by means of the collodion and clove-oil fixative. However, when they were intended to be stained afterwards, the water method was resorted to instead.

For staining sections on the object-glass, I have come to have a decided preference for the aqueous solution (3% or stronger) of acid-fuchsin (fuchsin S). It stains quickly and intensely, sharply defining the outlines of trabeculæ and the beams of the membrana reticularis. I have never gained much by double-staining. This is probably due to the extremely simple state of histological differentiation in the tissues and the consequent lack of parts (except the nuclei) which show any striking difference in the power of selecting stains. It would likely have been a different thing if I had taken into the scope of my investigation the nuclear structure and changes, which I did not.

EUPLECTELLIDÆ.

Under this family the forms studied by me are as follows:

1. *Euplectella imperialis* Ij.
2. *E. marshalli* Ij.
3. *E. oweni* Herkl. & Marsh.
4. *E. curvistellata* n. sp.
5. *Regadrella okinoseana* Ij.
6. *R. komeyamai* n. sp.
7. ?*R. phœnix* O. Schm.
8. *Walteria leuckarti* Ij.

In the present contribution I propose to give in detail the results of my investigations in regard to these genera and species. In so doing I shall freely advert to questions of a more general bearing in order to make clear my own points of view.

Euplectella Owen.

I will let a summary account of the organization of the genus in general precede the special descriptions, since in this way many of my views can be dealt with once for all. I have also considered it necessary to connect therewith some explanatory remarks on the terminology adopted. Should this method make the account of the genus somewhat lengthy, I may be excused therefor on the ground that a corresponding curtailment will be thereby made possible in the later pages. For detailed statements of many of the facts in support of my generalizations the reader is referred to the descriptive sections.

General structure.—I regard *Euplectella* to be derived ontogenetically and phylogenetically from a primitive form with these characteristics: A thin-walled tubular body, macroscopically closed on all sides except on the upper terminal surface, where is found a close aggregation of openings, the oscula, which put the

so-called gastral cavity (paragaster, cloaca, atrium, &c.) in direct communication with the exterior; the lower end having a tuft of spicules which serve to anchor the body in the substratum. The oscula at the upper end convert that part of the body-wall into a structure appropriately called the *sieve-plate*. The inflow of water takes place from the entire external surface, which is in fact minutely and thoroughly perforated—that of the sieve-plate beams not excepted; the outflow takes place through the entire internal surface; and the final exit is through the oscula, i.e., the sieve-plate meshes.

That the *sieve-plate* is only a modified section of the general body-wall follows from its spiculation, which, as long since known (MARSHALL '75, p. 200; SCHULZE '95, p. 42), is fundamentally the same as in the lateral wall, as well as from the presence of flagellated chambers in the beams in exactly the same disposition as elsewhere.*

The above primitive form has been met with by myself as an ontogenetic stage in the post-embryonal development of *E.*

*It will be seen that I have used the term *osculum* in the sense of any single opening in the parietes which serves as an exit for water from the gastral cavity, instead of calling by that name, as has been done by several previous writers, the entire superior body-end occupied by the sieve-plate. In view of the above noticed nature of the sieve-plate and of the presence of morphologically and physiologically identical openings on the lateral wall, the usage I have adopted of the term seems the most conformable to the real circumstances and, at all events, the best adapted for the purpose of description; although it can not be denied that the entire sieve-plate area of *Euplectella*, &c., may exactly correspond to the single, large, terminal osculum of certain other genera.

So far as concerns the mode of origin of the sieve-plate, my view completely concurs with that expressed by MINCHIN (Quart. Jour. Microsc. Sci., N. S., Vol. XXXIII, p. 258). There can be no doubt whatever that the Euplectellid sieve-plate is formed by a breaking through in several places of the gastral cavity to the exterior. As regards its function, the writer just mentioned has remarked that it may be of use in guarding against the intrusion of animals into the gastral cavity, which opinion is very likely true. Whereas, KELLER'S (Zeitschr. f. wiss. Zool., LII, p. 362) idea that it is an arrangement for keeping off mud-particles, which are assumed to be continually descending from the upper layer of waters, seems to lack all grounds of plausibility so far as the matter specified is concerned.

marshalli (Pl. IV, fig. 6). Moreover, it is persistent in the genus *Holascus*.

That ground-form, in order to differentiate into *Euplectella*, essentially needs but to open on the lateral wall a number of additional oscula, which might conveniently be called the *parietal oscula* in distinction from the more primary oscules (i. e., the meshes of the sieve-plate). The parietal oscula (Dermalostien MARSHALL, parietal gaps or Wandlücken F. E. SCHULZE) are round, because isolated, unlike those of the sieve-plate, which, being crowded together, are more or less angular. It is interesting to note in this connection that in a certain Euplectellid (*Walteria flemmingi*) the entire lateral wall presents an appearance quite like that of the Euplectella sieve-plate. The parietal oscula are surrounded by a narrow, iris-like, circular membrane,—the *ocular membrane*, —formed by the confluence of cobweb-like trabeculæ at the edge where the external and internal surfaces join. The same membranous edge may sometimes be observed, though much less conspicuously, at certain parts of, if not all around, the sieve-plate meshes. The assumption that the parietal oscula can be closed by the activity of the tissues during life (MARSHALL '75, p. 197) is, in my opinion, without foundation and highly improbable. They are certainly not provided with a tissue which is any more contractile than the trabeculæ; let alone then a definitely developed sphincter muscle.

In my estimation, the parietal oscula are to be collated with those secondarily formed oscules, which are so commonly met with, to the utter confusion of the question of individuality, in all groups of the Spongida. *Euplectella* is then rather polyzoic than monozoic, if it be necessary to use such qualifying terms at all. In this genus, as also in *Regadrella*, *Tœgeria*, &c., the

parietal oscula are quite numerous and are distributed over the entire lateral wall with a certain regularity, which is conditioned by the arrangement of the principal skeletal beams as well as by the course and the degree of development of the external ledges soon to be noticed.

The inferior terminal area of the body-wall, circumscribed by the points of emergence of the basal spicules, either dies off at an early stage—thus widely opening the tubular body at this end—or persists as a thin soft plate, perforated by round oscula as in the case of the lateral wall (Pl. IV, fig. 5). This plate has been described by writers as the inferior sieve-plate; however, in view of its appearance which is widely different from the sieve-plate proper, and also for the sake of more convenient reference, I propose to call it simply the *bottom-plate*. It was first noticed by Marshall ('75) in some specimens of *C. aspergillum* and later by O. Schmidt ('80) in *E. jovis* and by F. E. Schulze ('95) in *E. simplex*. I have observed it in both *E. oweni* and *E. marshalli*.

The external surface of the sponge may be tolerably even the interspaces between the parietal oscula being only gently convex. In many species, however, these rise up into more or less pronounced ridges, the *parietal ledges*, which generally run, several nearly parallel together, along with one or another of the three (circular, longitudinal and oblique) systems of the skeletal beams, but they are subject to many variations and interruptions in their course (Pls. I, III, &c.).

At the upper end of the lateral wall and along the junction of this with the sieve-plate, there usually exists a collar-like ledge in a continuous ring. This is known as the *cuff* (Pl. II, fig. 8), a formation which essentially agrees in origin and struc-

ture with the parietal ledge and must therefore be regarded as such under special development.

The main mass of the cuff and parietal ledges, as in fact all parts of the lateral body-wall except the principal framework of the skeleton, consists of loose tissues (Flockengewebe, flake-tissues), which easily fall off on rough handling or can be pulverized by rubbing between the fingers.

The internal or gastral surface of the body-wall (Pl. II, fig. 5; Pl. IV, fig. 4) shows low and narrow ridges, mainly circular and longitudinal, brought about by the underlying principal skeletal beams (Pl. II, fig. 9), which are situated much nearer to this than to the external surface. Many of the quadrate meshes formed by the ridges contain each a depression, the bottom of which is perforated by a parietal osculum. Other meshes, the so-called 'interstitial' meshes, inclose one or more apertures of the larger excurrent canals, while smaller excurrent canals open everywhere on the ridges as well as on the surface of the perforated depressions.

Anatomically and so far as the soft parts are concerned, I consider the walls of all Hexactinellids as being composed of three layers (Pl. IV, fig. 28; Pl. V. fig. 36). These from the exterior inwards are successively: 1) The *external trabecular layer*, which corresponds in part with the ectosome of Sollas. 2) The complexly evaginated layer of *chambers*, constituting the essential portion of the choanosome. 3) The *internal trabecular layer*, which may partly develop into an endosome. The first and the third are histologically the same and may in that sense be united into one, so that we distinguish in a general way only two kinds of differentiated tissues, the flagellated chamber-wall (membrana reticularis) and the trabeculæ. What F. E. Schulze

has called the dermal and the gastral membrane are structurally not distinguishable from the more deeply situated trabeculæ. They belong, in my opinion, within the pale of these, differing only in their being somewhat membranously expanded in relation to their position at the limiting surface. (See anon under *E. marshalli*).

The outer surface of the choanosome in *Euplectella*, visible through the delicate cobweb-like ectosomal layer, is perforated by small apertures (ostia RAUFF) leading into the incurrent canals. The excurrent apertures (postica RAUFF), which are on the whole very much larger, open as already indicated freely on the gastral side, being not covered over by a continuously developed endosomal layer.

SPICULATION.—The triaxial spicules of Hexactinellids in general may primarily be separated into two groups, which morphologically are sharply defined. One of these comprises the hexasters or rosettes with their manifold varieties and modifications; while in the other should be put all the rest of the spicules—the hexactins and their direct derivatives by the suppression of one or more rays—which present on the whole much simpler and more primitive characters.

Hexactins and *their direct derivatives.*—These furnish *par excellence* the supporting spicules of the body. They fall under several categories, such as the parenchymalia, the dermalia, &c., according to different topographical and functional circumstances.

The *parenchymalia*, which term I use in a sense differing from F. E. SCHULZE's in so far as not to include the hexasters, have their seat in the choanosome. The more strongly developed spicules in this category are known as the *principalia*, in distinction from which the remaining parenchymalia of weaker development and somewhat subsidiary function may be designated

the *accessoria*. Of the latter, again, those that occur closely bundled together in association with the rays of the principalia, are called the *comitalia*. Other accessoria are situated in a nearly or quite loose and irregular arrangement.

In *Euplectella*, an important portion of the parenchymalia goes into the formation of an exquisitely lattice-like framework, the ground skeleton, extending throughout the entire lateral wall (Pl. II, fig. 9). It consists of the three well-known systems of beams or spicular bundles. The longitudinal and the more inwardly situated circular systems of beams have for their common principalia either large oxystauractins or oxypentactins (sometimes oxyhexactins with a small sixth ray). These are always so situated that the spicular center lies at the intersecting point, while of the two cruciately disposed complete axes, one goes into the composition of the longitudinal, and the other into that of the circular, beams. Herein is given the condition of the courses taken by the two beams just referred to. The fifth ray, if present, is radially and distally directed and may freely project out of the external surface. Should it be found desirable to divide the present *Euplectella* into two subgenera or distinct genera, I think the presence or absence of this distal ray ought in the first instance to be taken into consideration as a distinguishing characteristic. In those principalia, in which the transverse axis goes into the uppermost circular beam at the junction of the lateral wall with the sieve-plate, the superiorly directed ray may be entirely wanting or may be shortly developed and extended into the sieve-plate beams. Moreover, these principalia may frequently possess a short distal ray entering into the cuff, even though they be without such a ray in other positions of the wall.

The comitalia to the principalia above mentioned are pre-

dominantly slender triactins, which I propose to call the *thetactin* in view of the T-like disposition of their rays. Occasionally there occur comitalia of other forms, as the commonest of which may be mentioned linear diactins and a variety of tetractins, which, unlike the stauractin, consists of two rays in a straight line and two lateral unpaired rays. I have called this sort of tetractins the *paratetractin*, being at loss for a better apellation. All the comitalia lie bundled together with their prolonged complete axis, while the lateral unpaired rays project forth from the bundle at indefinite intervals and in various directions.

The oblique system, which consists of two sets of right and left handed spiral beams, is usually less strongly developed and weaves its way mainly between the two other systems. However, it anastomoses not infrequently with either of these, and occasionally some of its beams are seen to intersect the circular beams on the inside, while a goodly number pass on to the outside of the longitudinal in order to communicate with the looser parenchymalia on that side. The spicular composition is essentially the same as in the other systems; only the principalia are here furnished by thetactins or diactins in the absence of either stauractin or pentactin principalia.

The parenchymalia of the sieve-plate are afforded by continuations of the longitudinal and oblique beams, especially of the former (Pl. IV, fig. 4). However, in most species the principalia are here chiefly oxydiactins bent more or less in accommodation with the irregularities of the sieve-plate beams; the accessoria are mainly diactins and thetactins. In some species (f. i., *E. marshalli*), the thetactins may predominate over all other forms of spicules, furnishing alike the principalia and the comitalia of the sieve-plate parenchymalia.

While in certain species the spicules of the skeletal framework remain perfectly separate throughout life (f. i., in *E. marshalli*, *oweni*, *curvistellata*), in others they begin at a certain age to undergo fusion by means of synapticulæ. The soldering together is nearly exclusively confined to the beams above described and to their direct continuations into the sieve-plate. The process seems always to commence at the lowest base of the sponge-wall and to proceed gradually upwards, either to stop at some point on the sides (f. i., *E. imperialis*) or to extend up into the sieve-plate beams (*E. aspergillum*). In view of the fact that in so many sessile Lyssacina exactly the same fusion of spicules first takes place where the surface is in contact with the substratum, I am led to the assumption that the latter exercises a certain influence in inducing the soldering process in question. The cases of *Euplectella* species, in which the soldering never takes place, may be explained by the fact that in them the lowest end of the body-wall is not in direct contact with, but stands above, the bottom-surface. That the basal tuft never becomes ankylosed, though penetrating quite into the substratum, is evidently due to its being devoid of living soft parts.

Apart of the above framework, the main mass of the choanosome is supported by numerous other parenchymalia of variable size and strength (principalia and accessoria), arranged either loosely in indefinite order or grouped into strands running in various directions. The forms of individual spicules are here again predominantly thetactins; less frequently hexactins, paratetractins and diactins, and rarely pentactins or stauractins. These constitute the principal part of the so-called flake-tissue or 'Flockengewebe' investing the skeletal latticework of the lateral wall on the external side and forming the main mass of the ledges.

The *dermalia*—which term I adopt in the sense of spicules arranged in a layer or layers in the ectosome and at the most peripheral position in relation to all other parts of the skeleton, not in the narrower sense of spicules belonging to the so-called dermal membrane—are always sword-shaped hexactins (Pl. IV, fig. 28; Pl. V, fig. 36; &c.). The greatly prolonged, proximal blade-ray penetrates the choanosome like a nail and materially contributes to the firmness of the latter. The distal hilt-ray is the shortest, but is not otherwise strikingly distinguished from the rest of the rays. The paratangential guard-rays of separate dermalia form at places a tolerably regularly quadrate-meshed latticework. This lies a short distance below the external bounding surface which is lifted up by each hilt-ray in a tent-like manner. This position of the dermalia would account F. E. SCHULZE's constantly calling them the hypodermalia. To me it seems that this 'hypodermal' situation is simply due to the presence of the distal rays; were these to atrophy, the trabeculæ outside the paratangential layer would lose their support and cease to exist, whereby the said layer would be brought to a position as superficial as the 'autodermalia' of certain other families (Caulophacidæ, Rossellidæ). Hence, I have considered it more in conformity to the circumstances to call the single-layered spicules in question of *Euplectellidæ* simply the dermalia, reserving the terms autodermalia and hypodermia for use only in the cases, in which the dermalia are differentiated into an outer and an inner layer respectively.

In *Euplectella*, the hexactin-dermalia along the edge of the cuff and of certain parietal ledges may in some species be considerably larger and stronger than those on the general surface. And, frequently some of these large dermalia are seen situated

more or less below the general level of the layer and seem to furnish connecting links between the dermalia and the hexactin-principalia of the parenchymalia, indicating at the same time their origin among the latter and their subsequent shifting to the rank of the dermalia.

The *gastralia* are always pentactins distributed without regularity. The unpaired distal ray dipping into the choanosome is usually much longer than the paratangentials. The same spicules extend into the excurrent canals as the *canalaria*.

On the sieve-plate beams, both the hexactin-dermalia and the pentactin-gastralia are as a rule tolerably stout-rayed and have the ray dipping into the parenchyma not specially elongated more than the rest. The paratangentials are in direct contact with the compact strands of parenchymalia. Especially the dermalia lie closely crowded together lending a close-grained appearance to their side of the beams.

As *oscularia* I propose to call the peculiarly developed spicules occurring in a ring-like zone in connection with the parietal oscula of many *Euplectella* species (Pl. II, fig. 17 ; Pl. IV, figs. 27, 28 ; &c.). They may lie partly in the iris-like ocular membrane but are mainly situated on the gastral surface around it. Here the zone appears as a whitish ring, forming a portion of the wall of the gastral depression, the bottom of which is perforated by a parietal osculum. This real position of the oscularia has been correctly recognized by F. E. Schulze in certain species ; however, to Marshall it was apparently not exactly known, a circumstance which may have had much to do in leading that writer to the assumption that the parietal oscula could be closed by the spreading out of the closely crowded oscularia ('75, p. 195).

The oscularia are small or medium-sized but mostly stout spicules with a variable number of rays. Nevertheless, many *Euplectella* species have each a certain characteristic form predominating amongst them, so that they are of considerable importance in the systematic of the genus. They lie, not in a single layer, but superposed in several layers. The more deeply situated and also those in the periphery of the ring are the larger; and especially the thetactin or diactin forms in these situations lead over the oscularia into the parenchymalia on the one hand, while on the other hand certain pentactin-forms mediate their transition into the gastralia. It is then not without justification that F. E. SCHULZE has referred them at one time to the parenchymalia (*E. aspergillum*, *oweni*; '87) and at another to the gastralia (*E. regalis*; 19', p. 29).

The oscularia begin to develop some time after the first breaking through of the parietal oscula; hence, they may be entirely absent or only scantily developed in quite young specimens or in those oscula which have but comparatively recently originated at the growing upper end of the body. This circumstance may at least partially account for the fact that in several known species of the genus the oscularia have remained undiscovered. I can not explain their non-occurrence around the sieve-plate meshes, unless it be that the rigidity, which they undoubtedly give to the parts occupied by them, is here sufficiently provided by the compactly arranged parenchymalia and gastralia so as to make their presence dispensable.

The category of spicules or spicular rays, collectively called the *prostalia*, is in all cases either intimately associated genetically with the parenchymalia or may even be the protruded parts of the parenchymalia themselves. In *Euplectella*, three sorts

of prostalia are to be distinguished: Firstly, the distally directed ray of pentactin or hexactin parenchymal principalia, already noticed as occurring in the circular and longitudinal skeletal beams of certain species. Secondly, slender oxydiactins swollen at the spicular center; these occur usually comitalia-like along with the radial rays of dermalia and are often protruded externally in bristle-like bundles, especially at the free edge of the cuff and of certain parietal ledges. Thirdly, the basalia or the anchoring spicules, which are by far the most conspicuous and important of all the prostalia.

The *basalia* are as a rule pronged thread-like diactins, the distal ray of which is exceedingly short in comparison with the excessively prolonged proximal ray, but is terminally provided with a miter-shaped knob, the anchor-head, supplied with a whorl of retroverted anchor-teeth (Pl. II, fig. 16; &c.). The latter are, as has been enunciated by previous writers, to be regarded as secondary prongs—not rays. A short distance above the head is the spicular center, at once recognizable by the axial cross within. In the head, the inferior extremity of the axial filament is either irregularly swollen or split in a penicillate manner into a few diverging branches. From about the spicular center upwards for a considerable length, the anchor-shaft is armed with barb-like prongs, arranged in a broken spiral line but at times disposed somewhat irregularly. The upper portion of the shaft is perfectly smooth and thins out superiorly to a fine point. The above basalia are grouped in bundles running along, and in direct apposition with, the external side of the longitudinal skeletal beams in the lower part of the sponge-wall. In forming the basal tuft, the bundles emerge from the parietal tissues in a circle around the inferior end of the lateral wall,

which is either open or closed by the bottom-plate. The sponge throughout life is constantly regenerating and projecting new anchoring spicules; hence, young specimens of the same of various lengths are always to be found in abundance with head and shaft still contained in the bundles within the parietes. With the continued elongation of the shaft, which takes place particularly in the proximal ray, they are protruded downwards, the head-end first, to be driven further and further into the substratum.

Exceptionally, the barbed basalia may be monactins brought about simply by the entire obliteration of the distal ray, thus bringing the axial cross to a position within the anchor-head. Such a modification seems to exist in *E. crassistellata* F. E. Sch. ('87, p. 82) and also in *Placopegma solutum* F. E. Sch., a peculiar form which is not without affinity to the Euplectellidæ. For the latter species F. E. Schulze ('95, p. 65) has expressly stated that the anchor-teeth, four in number to each head, are to be considered not as secondary spines but as real rays,—a view which is not acceptable, since the transverse axial canals as plainly shown in his figure are very short and far from extending even to the base of the teeth.

On the other hand, an essentially different type of anchoring spicules—genuine pentactin anchors—has been discovered by F. E. Schulze as occasionally present, in addition to the barbed diactin type, in the root-tuft of certain *Euplectella* species (*E. aspergillum, simplex, asper*). The unpaired ray is prolonged into the shaft which is perfectly smooth, while the short cruciately disposed rays at the inferior end are recurved and form the anchor-teeth. The latter are each traversed throughout by the axial canal.

Hexasters.—These are, according to my conception, minute hexactins which are invariably characterized by the presence of a number of slender, radially disposed secondary appendages—the terminal rays—at the outer end of each ray. The axial canal (Pl. IV, fig. 20; Pl. V, figs. 30-34) is confined to the latter, which is called the principal ray, and never extends into the terminal ray, as can be easily demonstrated by examining the spicule in a medium whose refractive index approaches that of the siliceous matter. Not unfrequently the principal possesses but a single terminal by reduction, and when the two are in a straight line, as is often the case, the external appearance is exactly like that of a simple primary ray. However, the exclusive presence of the axial canal only at the base will at once reveal the composite nature of such an apparently simple ray.

The most constant form of hexasters in *Euplectella* is the *floricome*, which I regard as a variety of discohexasters. The terminal disc, instead of being uniformly developed all around, possesses strong marginal prongs only on the side turned away from the axis of the perianth of the terminals, while on the opposite inner side the disc-edge remains smooth and obtusely rounded, being only indicated by a hump-like curvature of the surface (Pl. II, fig. 14, *d*; &c.). A parallel case of the same modification is found in a new octasterophorous Rossellid, which will be described under the name of *Rhabdocalyptus unguiculatus*; in this, the discoctaster exhibits a similar hand-like development of the terminal discs.

In their general shape the floricomes show no noteworthy variation in the different species of the genus. Therefore, in this respect, as also in that of the number of terminals in a perianth or of marginal prongs on the terminal plate, they are scarcely

of importance in the systematic of the genus, save that their size has in certain cases been found to be of use in the specific distinction.

The place and manner of origin of the floricome as well as its subsequent history seem not to have been followed out with accuracy by previous writers. It arises among the external trabeculæ beneath the dermal latticework. At a certain stage of its development, the terminals are short and exceedingly fine (Pl. II, fig. 10, Pl. IV, fig. 11 ; &c.). By the time the perianths have reached the definitive shape and size by the elongation and flaring out of the still slender terminals, the entire rosette is of the form which has been called by F. E. SCHULZE the sigmatocome (Pl. II, fig. 11 ; Pl. IV, fig. 12) and which he has apparently taken for a separate category of hexasters in *E. regalis* (19', p. 28). The distal portion of the terminals continues to thicken ; then, the rudiment of the terminal disc is formed (Pl. II, figs. 12, 14 ; Pl. IV, figs. 13, 14), which stage in the development of the floricome has already been recognized by F. E. SCHULZE in *E. aspera* and *Dictyaulus elegans* ('95, pp. 29, 41). However, that writer seems not to have observed its much earlier stage in which the terminals are still quite short, and evidently on that account, it appeared to him that all the radial rays attained their full length, though much more slender at first than in the later state, immediately upon their origin (*l.c.*, p. 41). This is at any rate not quite true with the terminals of the floricome. They do grow gradually in length during their development, an observation which I have found perfectly corroborated in the development of the graphiocome also (Pl. V, figs. 32-34).

The floricome, after the complete development of its parts, seems not to be destined to remain at the *locus nascendi* but to

be normally moved off towards the external surface, finally to take a position at the extreme outer end of the distal rays of the dermalia (Pl. V, fig. 36). Analogous to the rhabditi of Turbellarians, the floricomes originate in deep parts and shift themselves over to the most superficial situations to effectively discharge their function as defensive weapons. This point in their history seems to have been hitherto entirely overlooked. As is well known, it is usual to find a floricome to the tip of each dermal hilt-ray on depressed and therefore more protected parts of the external surface; whereas on more exposed parts, as on the ledges, it is frequently missing or exceedingly rare.

The *graphiocome* may fairly be said to be tolerably constant in *Euplectella*, notwithstanding it has not yet been discovered in certain species (*E. regalis*, *cucumer*, *suberea*, *jovis* & *crassistellata*). I think that at least some of these species may yet be discovered to be not totally wanting in the said rosette. Whenever present, it is found, like the floricome, exclusively in the external trabecular layer. A remarkable fact, which has not been noticed by previous writers, in connection with the rosette in question, is, that the sheaves of the fine needle-like terminals are exceedingly liable to break off close to the discs at the outer end of the principal rays, after the rosette has attained its full size. I believe that this breaking off is in fact a normal process, by which the rhaphides—a name that has been given to the liberated terminals without the knowledge of their genetic connection with the graphiocome—are put in a position to be moved off, with one of their ends pointed outward, towards the external surface, probably by the same force that drives the floricome in the same direction. Finally they are found in the most peripheral positions on the wall either scattered or in groups and

especially in intimate association with the hilt-rays of the dermalia, with their outer ends at, or sticking out of, the external bounding surface (Pl. V, fig. 36). In such a situation and arrangement, the rhaphides would serve in their own way as a powerful defense against attack from without. The excessive abundance of broken off oxyhexaster-terminals in perfectly undisturbed specimens of certain Rosselid species has given me the impression that the phenomenon is not peculiar to the graphiocome alone.

The *oxyhexasters* (Pl. II, fig. 15; &c.) have been found in all *Euplectella* species, except in *E. simplex* and *E. nodosa*. Unlike the other rosettes already referred to, these occur in both the external and the internal trabecular layer. In these positions they should serve as a defense against pernicious intruders. While in *E. oweni* and *curvistellata* the oxyhexasters were quite plentiful, I have found them rather sparingly in *E. marshalli* and *imperialis* and particularly so in the outer trabecular layer, —a circumstance which may be correlated with the especial abundance of graphiocomes in the two last mentioned species.

The entire size of oxyhexasters and the different development of their parts are of value, though not universally, in the distinction of species. A very noteworthy modification of the oxyhexaster is the clasp-like or sigma-like fibula of *E. jovis* (also found in another Eupectellid, *Holascus fibulatus*), the true nature of which has been perceived by F. E. Schulze ('87, pp. 78, 88). We have here to do with a diactinose oxyhexaster, probably derived from such a form as I have called the hexactin-shaped or hexactinose oxyhexaster (Ijima '97, p. 45; 'Derivate-Oxyhexaster of Schulze, '99) in which each principal has only a single terminal, in a manner analogous to that in which a rod-

like diactin is derived from a simple hexactin by the suppression of the four cruciately disposed rays.

Of special interest is *E. suberea* W. Thoms. in that it gives some clue to the genetic relation between the oxyhexaster and a form of discohexasters, the onychaster (Pl. X, figs. 12, 20, 21), which appears strikingly like the former but is distinguished by having exceedingly fine claw-like or branch-like appendages at the outer end of the terminals. It is known with certainty that certain individuals of that species possess true oxyhexasters in abundance (Schulze '99, p. 19; Topsent '92, p. 24). Now, Topsent (*l.c.*) made the interesting observation that in a specimen examined by him the oxyhexasters were entirely replaced by onychasters, and further that in another specimen there occurred neither the one nor the other in typical development but a form combining the characters of both in that one or more of the terminals bore each a single hook at the free end, while the rest terminated in simple points. The onychaster was evidently also seen by W. Thompson in one or the other of the specimens obtained by the 'Challenger,' for we see one represented in fig. 8, Pl. V, of the Challenger Report, which plate was prepared by that eminent naturalist, although in the text of the report Schulze held the spicule of that figure to be of extrinsic origin. With respect to what might be called the onycho-oxyhexaster discovered by Topsent, that writer justly concludes that it represents a form intermediate between discohexasters and oxyhexasters. Cases suggestive of the same transition are also known in the genus *Aphrocallistes* (*A. ramosus, bocagei*; Schulze '95, pp. 77, 80).

Which of the two hexaster-forms, the onychaster or the oxyhexaster, is then the more primitive? Taken alone, the onycho-oxyhexaster would look just as much like an oxyhexaster on the

verge of developing into a discohexaster as like a discohexaster just before losing the last vestige of the terminal armature. Nevertheless, I believe that discohexasters in the broad sense are all to be regarded as having been derived from oxyhexasters by complication of parts. I say this not on purely *a priori* grounds alone but also from the nature and mode of the growth of hexaster-terminals in general. Concerning the oxyhexaster of *Euplectella* in particular or of the onychaster of any genus, I have made none or but little direct observation as to the development of the terminals. However, in certain Rossellid species I have not infrequently met with unusually small oxyhexasters of typical shapes, in which the terminals were presumably still growing. How these grow in the floricome (a discohexaster) and the graphiocome (an oxyhexaster), has already been referred to in brief and will be described in greater details under *E. marshalli*. These observations seem to sufficiently warrant the induction that the hexaster-terminals are in all cases secondary appendages at the outer end of the principals or primary rays which alone inclose the axial filament,—local formations which at their incipient stage are exactly comparable to the simple microtubercles or spines that so frequently beset the spicular surface. It appears then assumable that the discohexaster-terminals originally ended in simple points as the oxyhexaster-terminals always do and that the terminal disc or whorl of claw-like processes is, so to speak, a tertiary structure added to the simple end of the terminals after these had grown to their full length,—a factual demonstration of which changes is found in the development of the floricome. Thus the ontogenetic and phylogenetic sequence of discohexasters to oxyhexasters in general seems to be plain, and the onycho-oxyhexaster probably represents a stage of the passage of the

latter into the former. And yet, in view of the indubitable cases of oxyhexasters reverting back again into the more primary hexactin-shape (hexactinose oxyhexaster), a somewhat analogous retrogression of discohexasters into oxyhexasters may be said to be not altogether impossible to imagine. However, if this really takes place at all, it must be of casual occurrence and would require special circumstantial evidence in order to be recognized as such. The presence of the incipient forms of discohexasters, i.e., the onychasters, among isolated members of different families (Euplectellidæ, Melittionidæ) would probably require for its explanation an assumption of its independent origination at separate points in the phylogeny by convergent adaptation.

In all thirteen species of *Euplectella* are to be considered as known at present. I will on the next page annex a key to all these species, which should bring out the main points of their structural differences and indicate to some extent the affinities existing among them.

Key to the Species of Euplectella.

a.—The parenchymal principalia of the circular and longitudinal skeletal beams are stauractins.

a^1. Spicules of the skeletal beams never in fusion.

a^2. Parietal ledges well developed; oscularia of miscellaneous forms..... .....*E. marshalli* Ij. (Sagami Sea; Suruga Gulf).

b^2. Parietal ledges little or not at all developed; oscularia mainly diactins.

a^3. Oxyhexaster with straight terminals, 50-70 μ in diameter ....*E. oweni* Herkl. & Marsh. (NW. of Kyūshyū).

b^3. Oxyhexaster with terminal rays bent near the outer end, 75-100 μ in diameter. ..... *E. curvistellata* Ij. (S. of Kyūshū).

b^1. Spicules of the skeletal beams in fusion, at least in the basal region.

c^2. Parietal ledges not developed; all meshes of the skeletal framework with a parietal osculum each; oxyhexaster not present ....*E. simplex* F. E. Sch. (Sea of Bengal).

d^2. Parietal ledges or protuberances well developed; a number of the meshes of the skeletal framework without parietal oscula; oxyhexaster present.

c^3. Ledges cut up into irregular knobs, flaps, &c.; oscularia chiefly hexactins and pentactins ....*E. imperialis* Ij. (Sagami Sea; Suruga Gulf).

d^3. Ledges with tolerably sharp continuous edges.

a^4. Ledges low; without graphiocome...*E. regalis* F. E. Sch. (Sea of Bengal).

b^4. Ledges prominent; with graphiocome...*E. aspergillum* Ow. (Philippines).

b.—The parenchymal principalia of the circular and longitudinal skeletal beams are all or at least partially oxypentactins, or oxyhexactins with one ray directed distally and radially.

c^1. The parenchymal principalia are oxyhexactins with a reduced proximal ray. Stauractins may occur in addition.

e^2. Distal ray of parenchymal oxyhexactins armed with prongs and conspicuously projecting out of the external surface. Oxyhexaster with short slender principals and long terminals .....*E. aspera* F. E. Sch. (Indian Ocean).

f^2. Distal ray of parenchymal oxyhexactins smooth, not freely projecting (?); oxyhexaster with moderately long and thick principals and short terminals..... .....*E. crassistellata* F. E. Sch. (Mid-Pacific).

d^1. The parenchymal principalia are smooth oxypentactins with entirely suppressed proximal rays. However, oxyhexactins may occur in addition.

g^2. Distal ray of parenchymal oxypentactins reaching to the external surface but not beyond; yet, with outwardly projecting bundles of small thin diactins; no oxyhexaster .....*E. nodosa* F. E. Sch. (Bermudas).

h^2. Distal ray of parenchymal oxypentactins freely projecting out of the external surface.

e^3. Oxyhexaster represented by clasp-like or sigma-like fibulæ (oxydiaster); oscularia scepter-like monactins .....*E. jovis* O. Schm. (W. Indies).

f^3. Either typical oxyhexaster or onychaster present; no fibulæ.

e^4. Body tubular, scarcely bellied; spicules nowhere in fusion; oscularia rough rod-like diactins.....*E. suberea* W. Thoms. (Atlantic).

d^4. Body distinctly bellied; spicules in fusion in certain parts; oscularia unknown .....*E. cucumer* Ow. (Seychelles).

EUPLECTELLA IMPERIALIS Ij.

Pls. I & II.

? *Euplectella oweni*, Schulze, '87, p. 81.
Euplectella imperialis, Ijima, '94, p. 365.

In F. E. Schulze's 'Challenger' Report (p. 81) it stands recorded that there was found among the Japanese Hexactinellida collected by Döderlein—in addition to a specimen of *Euplectella oweni*—a completely macerated and much injured skeleton (320 mm. long) of *Euplectella*, in which the spicules seemed to be loose above but below were fused into a firm latticework. This was assumed as belonging to a very large and old individual of *E. oweni*, in which the usually unfused spicules had become soldered together. To my knowledge such a fusion of spicules never takes place in the species mentioned (see anon under *E. oweni*). It therefore seems to me likely that Schulze had before him the specimen referred to by Döderlein ('83 p. 105) as having been obtained by purchase at Enoshima; and that, particularly in view of the above mentioned character of the skeleton, it belonged to the species which I am now going to describe under the designation of *E. imperialis*.

A preliminary account of this species was given in 1894 in the Zoologischer Anzeiger. Since that period no less than fifty specimens have passed through my hands, including all sizes from one of only 30 mm. up to a giant of 825 mm. in length. They were mostly collected by Kuma.

To give the exact localities where they were obtained: The majority came from Yodomi (both Naka-no-Yodomi and Maye-

no-Yodomi; 313-548 fms. [572-1002 m.]) and Okinosé (Inside and Outside by the Bishamon-line,* the Iwado-line, &c.; 235-313 fms. [429-572 m.]). At Yodomi, Mr. TSUCHIDA and myself had the good fortune to capture some with our own hands. Several specimens also came from Homba and a few small individuals from Gokeba. Further in 1899 KUMA obtained for Mr. OWSTON a specimen off Tago (on the western coast of the Prov. of Izu) in Suruga Gulf near the 200 fathoms-line; this specimen was identified by me as belonging to the present species.

I should put the bathymetrical range of *E. imperialis* as at present known at 200-548 fms. (365-1002 m.). It is evidently an inhabitant of deeper waters than *E. marshalli*, which does not occur at a greater depth than 160 fms. Besides, the nature of the bottom differs with the two species, as is attested by the matter interlocked in the basal tuft. While in the case of *E. imperialis* this consists almost purely of volcanic mud or sand of a gray color in the dried state, in the case of the other species the included matter is invariably shelly.

In the fresh state the color of the sponge is a pale yellow, often appearing rather dirty, being soiled by the mire of the bottom. To the same cause is to be ascribed the grayish color assumed by some specimens on drying, which otherwise should become perfectly colorless. Preserved in spirit the natural color is dissolved away.

GENERAL CHARACTERS OF NEARLY OR QUITE FULL-GROWN SPECIMENS.

E. imperialis shows many points of close agreement with *E. aspergillum* in regard to external form and structure, indicating

*I have not put down this line on the chart of Pl. XIV. It lies between the lines of Iwado and Sengenzuka: Togeyama -o- the Village of Bishamon.

a near relationship between the two. As in that species, the tubular body usually exhibits a simple, horn-like curvature, more or less pronounced according to individuals (Pl. I). However, nearly straight forms or those only slightly bent in S-like or irregular curves are by no means uncommon among the larger specimens.

The body is approximately circular in cross-section. This is at any rate constantly the case with the basal portion of the body; the upper portion may show certain irregularities in this respect. When quite full-grown the body is broadest at the upper end and gradually narrows below towards the bulbous basal tuft (Pl. I, fig. 1). In less advanced stages of growth, however, the shape is that of a slightly bellied tube, the broadest part being situated at or near the middle (figs. 2 & 3); otherwise, the breadth remains nearly the same from the broadest portion upwards to the upper extremity. It is clear that after a certain period of life, the growth concerns the upper region only, the lower portion admitting of little or no growth on account of the soldering together of the main skeletal elements, and that the continued growth in girth at the upper end after the growth in length has ceased, finally converts the original bellied tube into the cornucopia-like shape broadest at the top. Thus, the specimen shown in fig. 2 would have yet to grow broader in the upper region in order to attain the definitive shape, such as that of fig. 1. I may say that up to the stage when the body has grown to a length of about 300 mm., the shape of a bellied tube is invariably retained. Not unfrequently, the body considerably exceeds that length—in some cases reaching nearly 500 mm.—without deviating from the shape just referred to; while, on the other hand, others (e. g., specimen *D*

of the list appended below) may have already acquired the cornucopia-like shape when not much over a foot in height. The variation evidently stands in relation to that of maximum size, which different individuals are destined to attain.

The following are dimensions of several specimens which I have measured :

Spec.	Total length, basal bulb inclusive.	Height of body exposed above the sea-bottom.	Diameter close to the basal bulb.	Diameter at middle of body exclusive of parietal protuberances.	Diameter just below the cuff.	Remarks on body-shape.	
	mm.	mm.	mm.	mm.	mm.		
A	175	145	16	25	17	Bellied-tubular.	Curved.
B	230	190	18	25	19	„	„
C	250	230	22	30	19	„	Nearly straight.
D	387	335	28	41	53	Cornucopia-like.	Curved.
E	390	357	25	54–51	44	Bellied-tubular.	Nearly straight.
F	465	420	24	41–45	42	„ „	„ „
G	478	425	35	57–65	64–69	Cornucopia-like.	Curved.
H	490	436	25	37–45	34	Tubular.	Nearly straight.
I	515	445	29	49–58	58–69	Cornucopia-like.	Curved.
J	570	500	32	55–56	75–80	„	„
K	573	518	30	55–58	51–91	„	„
L	810	710	39	78–81	110	„	Slightly bent.

The thickness of the body-wall, exclusive of the parietal ledges or protuberances, does not exceed 2-3½ mm.

The diameter at the extreme lower end of the skeletal tube, inclosed in the basal tuft, is only about one-fifth of that at the upper end.

The *parietal ledges* or *protuberances* are very well developed and constitute a very characteristic feature of the species. They may in general be described as irregular ridges which are subject to frequent interruptions in their course and which, far from presenting even surfaces and edge-lines, are cut up into numerous tubercular, knob-like or flap-like protuberances that lend a peculiarly corrugated or jagged appearance to the sponge. In this respect the present species presents a striking contrast to its nearest allies, *E. aspergillum* and *E. regalis*.

At places the nappy ledges are seen running, numbers of them together, in an oblique direction, one way or the other, or in two intersecting oblique systems; in other places they may show an altogether irregular disposition, often bending, branching or anastomosing in their course. They are certainly less conspicuously developed in young than in old specimens. In the former there exists immediately below the cuff a narrow zone in which the ledges are scarcely or not at all developed (Pl. II, figs. 4, 6, 7); in the latter these may extend right up to, and join the base of, the cuff on its underside (Pl. I, fig. 1). Towards the lower extremity, the body is usually denuded to a greater or less extent of its peripheral loose tissues and with these the ledges also (figs. 1-3), thus exposing the bundles of basal spicules apposed to the skeletal latticework. So far as the prominences occur on the parietes, they are either tolerably uniformly developed all over the body or may show greatest development in the middle region. In the largest individual before me (spec. *L* of the appended table) some of them measure as much as 14 mm. in height above the level of the parietal oscula.

Certain flat lappets of the parietal ledge, particularly those with a sharper edge, are distinguished from the rest by having

a row of isolated bristle-like spicules standing out along the free edge to a length of about 4 mm. In some specimens such fringed lappets are not at all uncommon, while in others they occur only occasionally and may even be entirely missing. Rounded protuberances never exhibit the prostal spicules.

The parietal ledges form a rather steep wall to the valley-like, depressed spaces between them. These spaces are elongated or irregular in configuration,—generally meandering and intercommunicating, their shape depending upon the course taken by the inclosing ledges. Some of the more extensive, depressed areas may be said to have a comparatively flat surface.

The *parietal oscula,* which do not exceed 2 mm. in diameter, open on the depressed areas. Their thin edges lie nearly on a level with the general surface of the latter. They are usually found several together in the same area at intervals of 2-10 mm. from one another. The distribution is on the whole irregular, though often a number of them in succession are found in a line, the direction of which depends upon that of the long axis of the depression containing them. Exceptionally, isolated parietal oscula may open by means of a canal on the side or even on the summit of the external ledge. In specimens which are still actively growing at the upper end (figs. 3, 4), the openings are in that region arranged more or less regularly in transverse and longitudinal rows at short intervals. This regularity is however lost as the development of parietal ledges advances in that region.

The extremely delicate dermal latticework is, on close examination, just visible to the naked eye, except on the more elevated portions of the ledges, where the surface presents a rather close-grained texture. The apertures into the incurrent

canals, visible through the dermal layer, reach 1 mm. or slightly more in diameter.

The *cuff* (Pl. II, fig. 8) is thin and of varying width owing to the irregularly undulating character of the edge-line. The width also varies with the size of the specimens. In the largest individual before me (spec. *L* of the list on p. 62) it is 11-20 mm. as measured on the upper surface; 4-10 mm. in a specimen (*G*) 478 mm. high; and only 2 mm. in a specimen (*C*) 250 mm. in height. The free edge may show at places the same interrupted fringe of marginalia as those found on certain lappets of the parietes. The fringe is however of inconstant occurrence. The surface of the cuff presents a close-grained appearance unless injured.

The *sieve-plate* (Pl. II, fig. 8) is usually arched like a watch-glass, but the convexity may in some individuals be more strongly pronounced than in others. The entire structure appears rather frail owing to the comparatively thin beams and large meshes. The latter, in shape triangular to polygonal with rounded angles, are however of variable size, the larger ones measuring as much as 7 mm. across. Some of the beams are scarcely $^1/_4$ mm. thick at their middle, while others may be 1 mm. and more in width. The majority are more or less flattened in an externo-internal direction, the rest being more or less laterally compressed. The nodes are frequently thickened in a knot-like manner or widened into plates of considerable size. As in *E. aspergillum*, the entire sieve-plate presents the appearance of being divided by the stronger beams into a number of primary fields and these again subdivided by weaker beams into the in-

dividual meshes. Structurally the beams are compact, though the constituent spicules are never in fusion. On their internal surface are to be seen pores, which are the outlets of excurrent canals; for, the beams possess the chamber-layer, and the inflow and outflow of water evidently take place here as well as in the lateral wall.

Observations on growing individuals corroborate F. E. SCHULZE's view ('95, p. 25) with regard to the origin of new beams and meshes in the sieve-plate. These arise by the splitting and shifting asunder, as it were, of the beams and nodal plates already present. In other words, there arise in the tissues gaps which gradually enlarge into new meshes. I have also seen evidences of new beams, and therewith of new meshes, forming themselves along the inner border of the cuff.

Compared with the sieve-plate of *E. regalis* as figured by F. E. SCHULZE (19'), that of *E. imperialis* presents on the whole much larger meshes.

Whereas the greater upper portion of the sponge-wall possesses a certain degree of flexibility and elasticity, the lower portion is firm owing to the fusion of the principal skeletal elements in this region. As already mentioned, the lower end of the body is well-nigh or quite destitute of the loose tissues; in fact it may be considered as dead. Some distance before the extreme lower end of the skeletal tube is reached, the exposed longitudinal bands of the rather coarse looking, anchoring fibers begin to become frayed out inferiorly, soon to interlock among themselves and to penetrate into the bulbous mud-ball that always makes up the lower termination of the specimens. Not only the basal tuft but also the lowest end of the internal skeletal tube

itself penetrates the mud-ball. The sponge thus stands tolerably firmly implanted in the substratum, unlike certain other species (e. g., *E. marshalli*) in which the body, being rooted by the basal tuft only, apparently admits of being subjected to a free swaying motion as it stands on the sea-bottom.

The buried extremity of the skeletal tube, which is narrowed to about $^1/_5$ the diameter of the sieve-plate at the superior end and which is quite dead, is found to be open when cleansed of the mud; a perforated bottom-plate does not exist. However, in quite young specimens under 75 mm. body-length I have found the inferior end, which probably stands yet unburied in the mud, blindly closed by the living tissues (*vide* anon).

Turning our attention to the features of the parietes on the gastral side (Pl. II, fig. 5), this surface is as usual checkered with tolerable regularity by the transverse and longitudinal ridges. Much less conspicuous than these are the two systems of the right-handed and the left-handed oblique ridges. All the ridges bear numerous small excurrent apertures, generally not more than $^3/_4$ mm. in diameter. Many of the meshes too contain each one large or 2-4 smaller pits, which, by holding the wall against light, can at once be recognized as the apertures of large excurrent canals arising in the external parietal ledges. The rest of the meshes are each occupied by a cup-like or pit-like depression, the bottom of which is perforated by a parietal osculum. Not uncommonly two or more of these perforated meshes are found in direct succession either transversely or longitudinally. However, their distribution in relation with that of the other kind of the meshes—the so-called interstitial meshes—must be said on the whole to be irregular.

The meshes, whether perforate or interstitial, are nearly quadratic but often somewhat elongated in the longitudinal direction. They are usually largest in the middle region of the body, where they may measure as much as 4 mm. by 6 mm. (spec. *J* of the list given on p. 62). Towards either end of the body they diminish in size down to say 2-3 mm. in length of the sides.

The numbers of the transverse and the longitudinal ridges (which correspond to the main skeletal beams pursuing the same direction) as counted on two specimens (*D* & *J* of the list), both of which had fully acquired mature form, were as follows:

	Spec. *D*.	Spec. *J*.
Number of transverse beams	112	139
Number of longitudinal beams at the upper end	73 (?)	107 (?)
Ditto, at the middle	47	49
Ditto, at the lower end	27	25

In four more specimens—all macerated skeletons consisting of fused spicules—I have found the number of longitudinal beams at the lower extremity to be 22, 23, 23, and 28 respectively. It then seems that we shall not be wide of the mark in stating generally that the longitudinal beams in old individuals begin at the lower end with a number somewhere between 22 and 28, and that this number nearly doubles at the middle and triples or quadruples at the upper end of the body. It goes without saying that this multiplication is due to the splitting and divergence of the beams in their course. It often happens, especially close to the upper end, that the longitudinal beams are incompletely or but slightly shifted asunder, making it impossible to count their

number with exactness. Lower down on the body, the counting is however comparatively easy, as is also always the case with the transverse beams throughout the entire length of the body, these being everywhere relatively well separated.

Spiculation.

The *parenchymalia principalia* are large slender-rayed oxystauractins, in which the longitudinally disposed axis is usually much longer than the transverse. The former is straight and in large specimens may attain a length of nearly 100 mm. and a breadth of 180 μ or over near the spicular center. The shorter transverse axis may be 30 mm. long. The two lateral rays of this axis are somewhat inwardly directed as they arise from the center, so that they may enter into the composition of the transverse skeletal beams, which are more innerly situated than the longitudinal. Each point of intersection of the two main systems of the skeletal beams is usually, though not always, occupied by a single oxystauractin center; but not infrequently it shows none of this. Since therefore the rays are very much longer than the sides of the skeletal meshes, each beam of the skeleton is supported by several oxystauractin rays.

Along the inner border of the cuff, i.e., in the uppermost transverse beam of the skeleton, the principalia take a different form in that they are here usually provided with a short distal ray which extends radially into the cuff, while the superiorly directed, longitudinal ray becomes abortive.

The *comitalia* accompany the rays of the principalia in profusion. They are nearly exclusively elongate thetactins of quite a fine caliber. They may be 30 mm. long with a breadth

of 10-30 μ and more near the spicular center. The rays are for the greater part of nearly uniform thinness; the ends are slightly swollen and rough, the extreme tip being either rounded or bluntly conical. The unilateral ray may be of considerable length (up to 15 mm.) but more often it is relatively very short, being sometimes only 1 mm. or even less in length. It sticks out of the skeletal beams nearly vertically at indefinite positions and in all directions. Among the comitalia I have on rare occasions met with fine diactins in which the suppressed rays were represented by mere knobs at the center.

The longitudinal skeletal beams may attain a thickness of over 1 mm. The transverse beams are on the whole somewhat thinner.

The *oblique beams* of the skeletal framework consist, unlike those of the two other systems, almost entirely of thetactins which are however quite similar to those just described. Some of these thetactins may here be of moderate strength (up to 100 μ in thickness) and may be regarded as representing the principalia of the beams. Sometimes such stronger elements were found to be oxydiactins.

The spicules of the skeletal beams above referred to begin to undergo synapticular fusion in the well-known manner at the lower end of the body and that at a time when the sponge has acquired a height of about 200 mm. With further growth, the soldering gradually extends upward to about the middle of the body but probably never further than that; for, even in the largest specimen (*L*) before me, I find all the spicules in the upper half in loose association with one another. Here seems to exist another point of difference from the closely allied *E. regalis* F. E. Sch., in which the soldering process appears to

extend right to the upper end of the body, though not into the sieve-plate. By macerating large specimens and washing away all the free spicules, the wall of the lower half yields a skeletal tube consisting of a continuous, filigree-like latticework of the fused beams (Pl. II, fig. 9). The tube is narrowest and firmest at the lower end. At its upper end, the beams are frayed out into their separate fibers. The bundles of anchoring spicules, running along the longitudinal beams in the lowest third of the body, do not participate in the fusion except to a very inconsiderable extent in the deepest parts in direct contact with the beams proper.

The *anchoring spicule* or the *basalia* (fig. 16) may reach a length of 200 mm. or more and a breadth of 75 μ at the middle. The axial-cross lies at some distance (250-320 μ) from the extreme distal end, which is swollen into the usual miter-shaped knob (75-95 μ long, and nearly as broad) furnished with a whorl of 5-9 anchor-teeth. The latter are much smaller and shorter than in *E. marshalli* or *oweni*. Soon after its origin from the knob, the shaft is only 19-23 μ thick. The first barb-like spine, on following the spicule from the distal end, occurs shortly in front of or behind the position of the axial-cross. I observe no definite rule as to the arrangement of the spines on the shaft. They may extend proximally for nearly half the length or more of the entire spicule, imparting to that portion a peculiarly glistening appearance when seen with the naked eye. Proximally they become gradually smaller and wider apart until they altogether cease to exist, leaving the rest of the spicule perfectly smooth up to the finely attenuated upper end. Intermixed among the bundles of basalia-shafts on the sponge-wall, there are always

found, but more frequently in small than in old specimens, short and young anchoring needles in various stages of development. The anchor-heads attain full size in this position and are subsequently, along with continued elongation of the shaft, pushed on downwards, finally to penetrate into the substratum.

The *parenchymalia* which support the loose tissue covering up the skeletal latticework, are again chiefly thetactins with short unilateral rays; but not uncommonly they are also hexactins, usually with one axis which to a greater or less degree is more elongated than the others; and occasionally they are diactins, generally with knob-like indications of suppressed rays at the spicular center. Besides these, there may occur, though exceptionally, any other form of spicules. All are small to medium-sized spicules, $^3/_4$-7 mm. in length and with rays 15-30 μ thick near the center. The ends of the rays are sparingly beset with spinules and usually terminate in a conical point. These parenchymalia frequently combine into loose, ill-defined strands, which mostly extend peripherad; otherwise, they stand isolated either without any order of arrangement or with one axis pointing towards the surface.

Among the diactin-parenchymalia, those that are externally protruded as *prostalia* at the edge of the cuff and of certain parietal lappets, require special mention. We have here to do with slender oxydiactins of very variable size—up to 5 mm. in length and 20 μ in breadth—in which the center is indicated by a slight annular swelling. In the positions indicated, such oxydiactins are usually numerously present and disposed in radial arrangement. Some lie still completely imbedded in the body-wall; others are partially or completely projected out of the

surface in coherent bundles, which stand each in association with the distal ray of certain especially strongly developed dermal hexactins presently to be noticed. The bundles constitute the bristle-like prostalia already described. Just the same kind of prostalia is known to occur also in some other species; e.g., in *E. marshalli* Ij., *E. nodosa* F. E. Sch.

The *oscularia* (fig. 17) are mostly thick-rayed, plump-looking hexactins and pentactins. Both these forms occur in about the same numerical proportion. In addition to them, there also occur not uncommonly forms which nearly approach or virtually are stauractins or compass-needle-like diactins. Their size is exceedingly variable, those near the edge of the oscular membrane being much smaller than others situated in more peripheral positions in the zone. The former may measure only 120 μ in axial length and 15 μ in breadth of the rays, while some of the latter may attain 450 μ and 50 μ in the corresponding dimensions. The rays are either rounded at the end or pointed and conical in shape. The spicules lie thickly crowded for the most part in several layers and apparently without regularity as to the disposition of the axes in relation to the surface of the zone. In the case of oscula of comparatively recent formation, the oscularia are always much less numerous than in those of long standing. Noteworthy is the fact that there exist in the immediate neighborhood of the zone certain hexactins and pentactins, which, considered in respect of position, size and general appearance, might well be considered as standing intermediately between the oscularia on the one hand and the hexactin-parenchymalia and the pentactin-gastralia on the other.

The sword-shaped oxyhexactin *dermalia* of the general surface are comparatively small and slender, the ray usually measuring less than 1.5 mm. in length and 7-12 μ in breadth near the spicular center. The distal hilt-ray is only 130-180 μ long. Exactly as in *E. regalis*, it gradually tapers distally to a fine or conical point and shows obsolete prickles which stand closely together near the outer end but are isolated and sparingly present on the rest of the ray. The five remaining rays are rough only at the ends. The paratangentials (220-350 μ long) of different dermalia tend to form a rectangular meshwork (meshes about 3 mm. wide) in the depressed areas of the external surface ; towards the summits or edges of the parietal prominences the arrangement becomes irregular. The blade-ray, which pierces the choanosome like a nail, is usually several times longer than the hilt-ray,—occasionally only twice but more often it is nearly ten times as long.

Unusually large and strong hexactin-dermalia occur, together with others of the more ordinary dimensions, along the cuff-edge as well as on the highest parts of the parietal ledges, especially in conjunction with the bristle-like prostalia already mentioned. In these positions they may attain a size more than thrice as large as the ordinary dermalia. In one specimen measured the greatest axial length was 4.7 mm., of which 1.2 mm. belonged to the hilt-ray, the breadth of the rays near the center being 40 μ. While on the one hand there exist intermediate transitional forms between the large and the small dermalia, some of the former are, on the other hand, more or less deeply situated below the others, so that they appear sometimes not unlike hypodermalia or otherwise assume such positions as seem to justify their being taken for parenchymal oxyhexactins.

The *gastralia* are oxypentactins sparingly supplied with minute prickles at the conically pointed ends of rays. The paratangentials (200-450 μ long, 13-15 μ thick) are frequently of unequal length in the same spicule and more or less bent so as to form an irregular cross. The unpaired, distally directed ray is straight and somewhat longer. As in all other species of the genus, the gastralia are nowhere so regularly arranged as to form a quadrate meshed latticework. Quite similar pentactins extend into the excurrent canals as *canalaria*, which become more and more sparse toward the distal end of the canals.

The *floricomes* look exactly like those of other *Euplectella*. In diameter they measure 90-105 μ, say about 97 μ on the average. Only in very young specimens have I found them perceptibly smaller (84-91 μ dia.), but never so small as in *E. marshalli*. The number of terminals to each principal ray varies from 7 to 12. The terminal plate shows 5-9 sharp teeth on the external edge, while its internal edge is represented by a simple obtuse rounding of the surface, as is usual with all floricomes (Pl. II, fig. 14*d*).

In sections of a specimen 210 mm. long, I have found in abundance cases of the floricome in various stages of developing its terminals (figs. 10-12, 14). They were all situated in the subdermal trabecular space, which undoubtedly is the place where the rosette in question arises and reaches full development, eventually to be moved off to the apex of the hilt-ray of the dermalia. In the earliest stage observed, the six principals were already fully developed though still somewhat thinner than in the mature state. Each principal, traversed throughout by the axial canal, terminated externally in a lenticular disc, from the

margin of which arose a number of short, and uniformly exceedingly fine terminals in a single whorl. The terminals measured scarcely over 10 μ in length and together formed a wine-glass-like perianth (fig. 10). I have failed to discover a still younger stage, much as I have wished to do so; so that, the mode of development of the principals must ever remain entirely in the dark. On the other hand, I have succeeded in observing a continuous gradational series of forms leading from the above-described stage up to the completely developed floricome. The fine terminals elongate and by flaring out at the outer end convert the perianth into a deep bell-like shape (sigmatocome, fig. 11). (See p. 52). The outer portion of the terminals has somewhat thickened, but the extreme tip appears still pointed (fig. 14*a*). It continues to thicken especially at the tip; meanwhile, the latter passes into a state which, when observed under a high power, appears as obliquely and somewhat roundly truncated (fig. 12; fig. 14*b*). It may now show small rudiments of the marginal teeth (fig. 14*c*) and indisputably presents itself as an inceptional terminal plate of the floricome. Fig. 14 *d* represents a fully developed terminal in the same scale of magnification as the developmental stages *a*, *b*, and *c* of the same figure.

In *E. aspera*, F. E. SCHULZE ('95, p. 29) found the terminals of young floricomes with a knob-like swelling at the free end. In *E. imperialis* and *E. marshalli*, this is never exactly knob-like but rather obliquely truncated as already mentioned.

The *oxyhexasters* (fig. 15) measure 83-92 μ, mostly about 86 μ, in diameter. They are by far less numerous than the floricomes. While in some places in the deeper parts several oxyhexasters were found together at no great distances from one another, they

were decidedly rare in the parietal ledges. The principals are excessively short, being represented by a knob-like swelling separated from the central node by a narrow constriction. They are quite unlike those in *E. regalis*, in which, according to F. E. SCHULZE's representation, they should be short but narrow. The strongly divergent terminals, 3-5 to each principal, are smooth, nearly straight and of moderate length.

The *graphiocomes* measure up to 330 μ in diameter. They are tolerably common everywhere in the periphery of the wall, though it may be comparatively rare to meet with one in a perfectly intact state. The sheaves of terminals may be 154 μ long and 20 μ broad. Detached and isolated terminals—i. e., the rhaphides—are scattered here and there in the superficial region, lying irregularly but mostly more or less vertically to the surface along with the hilt-rays of the dermalia. In comparison with *E. marshalli*, the rhaphides so situated are not so numerous. The central remnant of the rosette after completely shedding off the rhaphidial terminals, has been very frequently met with. The discs at the end of principals are then seen studded all over their external surface with small prickles. Different stages of the growth of the terminal sheaf have also been found. The rhaphides composing each sheaf are at first very short and exceedingly fine (fig. 13). For further account of their development, see under *E. marshalli*.

In *E. regalis*, which clearly is very nearly related to the present species or to *E. aspergillum*, F. E. SCHULZE has entirely missed the graphiocome; nor does he appear to have seen any free rhaphides. Nevertheless, I consider it not altogether im-

possible that further research with more materials may reveal the presence of the rosette in that species also.

The *sieve-plate* presents a spiculation somewhat differentiated from that of the lateral wall. The principal parenchymalia are here oxydiactins, smooth at the center and gradually attenuating toward either end. They may attain 30 mm. or over in length and 190 μ in breadth at the center. They are usually more or less curved and often rather abruptly bent in accommodation to the corners of the sieve-plate meshes. The accessoria, copiously present and forming close bundles with the principalia, are likewise predominantly diactins and occasionally thetactins. The diactin forms show either annulated or cruciately tubercled centers. Certain diactins are remarkably short in relation to their thickness and may be called compass-needle-like. The external surface of the sieve-plate exhibits nearly regular hexactin-dermalia of 150-400 μ axial length, sparingly present on the thinner beams but densely crowded on the nodal plates. The rays in these spicules are relatively strong and acutely or bluntly pointed at the roughened ends ; the proximal ray pierces right into the subjacent parenchymal bundle. The gastralia on the inner surface are less abundant. They are pentactins of an appearance quite similar to the dermalia save the absence of the free ray. All the three forms of rosettes found in the lateral wall occur in the sieve-plate also,—the floricome and the oxyhexaster very sparingly but the graphiocome in abundance. Hence, free rhaphides are of quite common occurrence in the dermal layer. Finally, it may here be added that I have ascertained by sections the presence of the chamber-layer in the sieve-plate.

Young Specimens.

Of quite young *E. imperialis*, under 75 mm. length (excl. of the basal tuft), I have been able to bring together no less than a dozen specimens, of which the smallest (Pl. II, fig. 6) measures only 30 mm. in body-length and 10 mm. in greatest breadth. They may be described in general as follows:

The body is bellied in a spindle-like manner, straight or slightly bent and circular in cross-section. Inferiorly it narrows to a conically closed end, whence arise the basal spicules in a small, almost solid tuft. Above, the body contracts in a much less degree and ends almost truncated, the sieve-plate being only slightly convex. The latter structure is very frail, the beams being quite thin; the angular meshes number from about half a dozen to a score according to the size of the specimens. There is yet scarcely a trace of the cuff. Numerous small parietal oscula occur already in the smallest specimen above referred to. The general form thus closely resembles that of young *E. marshalli*, in fact I think of all *Euplectella* species in the corresponding stage of growth.

However, there are certain points by which the similarly sized young of *E. imperialis* and *E. marshalli* may be distinguished. Firstly, in the former the external surface presents a more jagged appearance and shows a larger number of small, bristle-like, prostal spicules, while in the latter the broader and more continuous parietal ledges present on the whole a nearly even surface (*cfr.* Pl. II, figs. 6 & 7 with Pl. IV, figs. 8 & 9). After attaining a body-length of about 70 mm., the parietal ledges in *E. imperialis* are already developed into the characteristic lappets or interrupted

ridges, which, in such young specimens much more frequently than in the older ones, are fringed with an irregular row of bristle-like prostalia. Fig. 3, Pl. I, may be taken as an illustration of the general appearance of the sponge at the stage in question. The parietal prominences are best developed on the middle of the body but are yet quite undeveloped close to the sieve-plate end. They are nowhere so conspicuous as in old specimens, but when compared with *E. marshalli* of about the same size, they give a jagged appearance to the sponge surface sufficient to serve as a distinguishing feature.

Secondly, the size of the floricome presents a certain constant difference in the two species. It seems that in all *Euplectella* species the said rosette is on an average somewhat smaller in young than in old specimens. Now, whereas in old *E. marshalli* it never exceeds 80 μ in diameter, all the small *E. imperialis* under consideration have it appreciably larger ; here the diameter may reach 91 μ or over, although some other floricomes in the same individual may run down to 84 μ in diameter.

Further there are some other points which at times may serve as an aid in referring young specimens to one or the other of the species in question. 1) The locality and depth from which the specimens were obtained ; for, so far as my knowledge goes, the two species seem to have each its own sphere of distribution both horizontally and vertically (see p. 60). 2) The character of the substratum as exemplified by the matter contained in the root-tuft ; for, while *E. imperialis* exclusively inhabits sandy or muddy bottoms, the other species is apparently confined to the coarser shelly grounds. 3) The species of the Crustacean immate (see anon, under Miscellaneous Notes). Constant as the difference in this regard seems to be, the drawback is that in

very young *Euplectella* the inmate is more often absent than present.

I may here add that the sieve-plate of young *E. imperialis* is perhaps less frail and less liable to be lost than in *E. marshalli* of a similarly small size; for, I have found it preserved intact in most cases of the former, while it was broken and lost in the majority of the latter. Further I may record that whereas in young *E. imperialis* the sieve-plate was always only flatly convex, it was often, though not always, much more prominently so in individuals of the other species in nearly the same stage of growth.

The approximate numbers of transverse and longitudinal beams of the skeleton, as counted on four small specimens of *E. imperialis*, were as follows:

Spec.	Size of body.		Number of transverse beams.	Number of longitudinal beams at middle of body.
	Length (excl. of basal tuft).	Greatest breadth.		
	mm.	mm.		
a.	32	8	30	26
b.	34	8	25	20(?)
c.	48	12	26+	23
d.	60	11	40	22

A comparison with the numbers of corresponding beams in fully adult specimens as given on p. 68, will at once show that those of the longitudinal beams in the young (last row of the above table) are, generally speaking, nearly equal to, or at any rate not widely at variance with, the same as counted at the lower end of mature specimens. This should mean that in the basal region the longitudinal beams develop to their full or nearly

full number at a very early period of life. With the growth in girth of the sponge, the beams in question become wider and wider set apart from one another, and if increase in their number takes place at all in the said region, it can not be to any considerable extent. An end is definitely put to their shifting asunder or their new formation by the soldering together of spicules, which process, as already mentioned, sets in at the sponge-base when the entire body has attained a length of about 200 mm. Quite a different circumstance should obtain in the upper region. With the growth of the body, many of the ever elongating longitudinal beams undergo splitting at indefinite positions in the circumference but especially frequently near the upper end towards the close of the growth, when that end becomes the broadest part of the entire body.

With respect to the increase in number of the transverse beams, the facts ascertained by F. E. SCHULZE ('95, p. 25) from *E. simplex* find corroboration in the present species. The most active seat of their multiplication is the upper end of the sponge close to the cuff, where they lie most closely together and are thinnest, being composed of slender and evidently young parenchymalia. Here the sponge-wall is youngest at all stages of its growth and the formation of new transverse beams may be said to be constantly taking place until the sponge has nearly reached its full length. After the expansion of the upper end into the broadest part of the wall, there no longer exist signs of their new formation.

The lower extremity of the body proper is, as already remarked, blindly closed at first and apparently lies free above the surface of the substratum, the sponge being rooted by the basal spicules only. Soon the condition changes. By the time

the sponge measures 75-100 mm. in length, the lowest end of the body encroaches upon and begins to bury itself in the substratum. This seems to cause degeneration of the soft tissues at the extreme inferior end, which henceforth remains open as before described. A perforated bottom-plate, such as occurs in *E. marshalli*, *E. oweni*, *E. jovis*, &c., does not here come into formation; it develops, in my opinion, only in those species in which the lower end of the body remains life-long apart from the substratum.

Miscellaneous Notes.

E. imperialis has recently been pointed out by F. E. Schulze (19', p. 29) as having its nearest ally in *E. regalis* of the Indian Ocean. I should think the latter species is about as nearly, if not more nearly, related to *E. aspergillum*. Indeed, so close seems the agreement between the single specimen on which *E. regalis* is based and the not fully mature specimens of the Philippine species, that, should the graphiocome come to be discovered in the Indian form—which contingency I presume to be not altogether unlikely with examination of more specimens—there would remain probably only some slight differences in external form to fall back upon as differential characters between the two species.

On several specimens of *E. imperialis* were observed unmistakeable signs of the regeneration of loose tissues at such parts of the external surface as had been stripped of the ledges and flake-tissues by some mechanical cause. Far more substantial deformities arise in connection with the repairing of such injuries as the breaking off, rending, twisting or bending of the

body-wall. Remarkable was the case of a specimen of medium size in which the body, instead of being tubular, was more like a compressed sac,—probably brought about in consequence of tearing and other injuries sustained by the wall at several points. The upper end of this specimen was closed by a sieve-plate which bore the appearance of having been secondarily formed after the loss of the original one. It would be superfluous to enumerate all the other cases of malformations due to similar causes.

Once a specimen was obtained which was normal in all respects except in bearing on one side near the upper end a second shorter tube, connected with the first by means of a short, solid, lateral bridge, through which the parenchymalia of the one tube passed into the other. The smaller tube thus appended looked very much like the upper torn end of a distinct individual, having a regular sieve-plate above but being closed by regenerated tissues at the opposite end. In fact I do not know how to explain this abnormality unless it be that we really have to do with such a portion of a separate individual which came into fusion with its neighbor previous to its becoming cut off from its basal region.

Finally a few words about the commensal inmates. It is interesting to note that the two species of *Euplectella* occurring in the Sagami Sea, viz., *E. imperialis* and *E. marshalli*, have each a special macrurous Crustacea as inmate in the gastral cavity. For the first named species, this was a species which unfortunately could not be satisfactorily identified, although Dr. KISHINOUYE for my sake kindly made efforts at its determination. It comes nearest to both Alpheidæ and Hyppolyt-

idæ and yet is not exactly admissible into either family. The body of the Crustacea, which may be about 40 mm. long, is laterally compressed; the keeled cephalon is bent in hump-like manner and supplied with a small rostrum; the eyes are exposed, not covered by the prolongation of the cephalic carapace; the mandibles with palpi; the third maxilliped robustly developed; the first leg chelate and symmetrically paired; etc. A noteworthy circumstance is the fact that this Crustacea occurs each time singly in the gastral cavity—not in a pair as is usually the case with *Spongicola venusta* of *E. marshalli* and *E. oweni*. The Crustacea was only exceptionally absent in the larger specimens of the sponge but quite frequently in the smaller under 75 mm. body-length. A certain relation seems to exist between the size of the inmate and that of the host, probably as the result of the former entering the latter when both are yet small and their continuing to grow together.

Once an oxyrhynchous crab, *Chorilia* (closely resembling *C. longipes* DANA), was found instead of the Macroura. Among the other inmates Ophiurons were not uncommonly represented by two or three different species at a time.

EUPLECTELLA MARSHALLI Ij.

Pls. III, IV & V.

Euplectella Marshalli, Ijima, '95, p. 93.

Under the above designation in 1895 I briefly described a second species of *Euplectella* inhabiting the Sagami Sea. Though evidently a very close relative of *E. oweni* Herkl. & Marsh., long known as from Japan, it clearly deserves to be considered as a distinct species.

E. marshalli became originally known to me from Dōketsba (see p. 13). Depth 75-160 fms. (137-292 m.); bottom shelly. As spots where one may be almost certain of securing specimens of the species, I may mention: *Matswa Lighthouse line* by *Mera* 2-3; *Ena line* by *Mera* 2-3; &c. Since the first specimen was brought to me by Kuma in 1894, scores must have been taken on the same ground by different collectors, I myself having to account for a goodly number. Apparently the species flourishes there in luxuriance, alone by itself and not in association with *E. imperialis*, which belongs to a deeper bottom of a quite different nature. It has thus afforded me a rich series of materials which has enabled me to institute a much closer study of it than of any other species of the Hexactinellida.

However, Dōketsba does not seem to be the only locality where *E. marshalli* is found. During the cruise of S.S. 'Ōnoura Maru' on behalf of the Fishery Bureau of the Japanese government in 1893, a young specimen, only 44 mm. long, was obtained off Okada, a small village on the northern coast of

Vries Island. Nothing further is known about the circumstances of its capture. The specimen was kindly given me by Dr. KISHINOUYE for investigation and I hold it as belonging to the species now under consideration. It contained in the gastral cavity a single *Spongicola venusta*.

Further on May 7, 1900, the U. S. Fish Commission Steamer 'Albatross' obtained by means of tangles a small, much macerated *Euplectella* at her Station 3700 (Senoumi in Suruga Gulf; depth only 73 fms. [133 m.]; bottom volcanic mud and sand). I was on board the ship at the time and although I could not undertake a microscopical examination of the specimen, I have judged it to belong to *E. marshalli* from its general external appearance. The Crustacean inmate was *Spongicola venusta*. The other catches at the same station were quite similar to those usually obtained at Dōketsba.

The general color of the sponge in the fresh state may be called a light salmon or a pinkish buff. It is deeper and brighter than in *E. imperialis*. When dried or preserved in alcohol, specimens become entirely colorless.

In fresh specimens obtained by me July 17, 1895 and April 1, 1900, I have noticed with the naked eye numerous small spots of a deep orange-yellow in the substance of the sponge-wall. The larger spots, irregular in outline, measured nearly half a millimeter across. They were most distinctly visible on the gastral side but were also present imbedded in the deeper parts of the parietal ledges. I believe the same spots are to be seen in a greater or less quantity in all individuals and at all seasons of the year. When put into alcohol, the orange-yellow color is dissolved away and the spots become lost in the general white-

ness of the tissues. In specimens preserved in weak formalin, the color has likewise disappeared but the spots remain distinguishable, being more opaque than the surrounding tissues. Osmic acid has blackened the spots. I think the coloring matter referred to, which is combined with oil-like spherules contained in the cells composing the spots, is the same as that which is diffused in the soft tissues and gives to these the before mentioned pinkish-buff color. The cells of the spots will find further treatment under the histology of the soft parts. (See anon under Thesocytes).

General Characters of Nearly or Quite Full-Grown Specimens.

The body may be described as a gently bellied tube with an irregularly corrugated external surface (Pl. III). The sieve-plate is strongly arched; the basal tuft, large and elongate. The broadest part of the body is usually, but not always, situated somewhat below the middle; so that, the general shape is frequently not unlike that of a lamp-chimney, while in others it more resembles a barrel or a cucumber. Young specimens show a shape approaching that of a spindle. The cross-section is on the whole circular, except at the extreme lower end which is as a rule more or less distinctly compressed. The following are measurements of some of the larger specimens taken up at random :

Spec.	Length of body (excl. of basal tuft).	Diameter of sieve-plate.	Diameter of body at the broadest part (external ledges included)*.	Diameters at the compressed lower end of body.
	mm.	mm.	mm.	mm.
A	122	25	44–54	23–27
B	122	30–33	45–53	14–25
C	143	32	55–59	17–31
D	144	21–29	44–52	12–14
E	155	28	46–48	12–16
F	182	41	63–65	10–34
G	193	35	60	15–37

Specimen *G* of the above list is about the largest specimen of the species I have as yet met with.

The body-wall measures not more than 3 mm. in thickness, leaving the height of the parietal ledges out of consideration.

The ratio of the body-length to the greatest breadth may be put down as 1 : 0.3-0.44. In comparison with either *E. imperialis* or *E. oweni*, the body is considerably shorter in relation to its breadth.

The *parietal oscula*, not over 2 mm. in diameter, are rather irregularly scattered. They lie in broadly pit-like or elongate valley-like depressions of the external surface, sometimes singly and at other times in groups, but without a definite rule as to their relative position. Those opening on the same depressed area are separated from one another by an interspace which is either gently convex or nearly flat and varies from 1 mm. to

*The fluctuation of diameter in the same individual, to be noticed in this column, is mainly due to the various degrees of the development of the parietal ledges at different points of the circumference. Leaving aside these ledges, the cross-section of the body may be said in general to be approximately circular.

5 mm. in width. Others separated by a prominent parietal ledge are frequently 8 mm. or more apart.

The *parietal ledge* is very well developed and gives a strikingly characteristic appearance to the sponge. It is broad and generally round-edged but quite irregular as to the course and configuration it takes. Sometimes it remains rather low and exhibits an approach to a checkered arrangement in that it runs in intersecting transverse and longitudinal systems (see fig. 2, Pl. III). Much more usually the ledges rise in irregular crests, lappets or tubercles of variable height and extent. These present an appearance on the whole quite different from those of *E. imperialis* in being broader and more bold in their outlines. The crests may pursue a plainly oblique course after the manner of those in *E. aspergillum* (fig. 1, Pl. III), but this is by no means general. In fact, they may run in any direction, often tortuously and as often branching and anastomosing in an altogether indefinite manner. They are generally in greatest development where the sponge-body is broadest. Here they may be 10 mm., sometimes even 15 mm., high, as measured above the level of the parietal oscula. Close to either end of the body, the ledges are on the whole low, though by no means uniformly so at different points or in different individuals.

Originally separate parts of adjacent ledges may, during growth, come into contact and fuse together. In this way is to be explained the origin of the bridge-like connections which have been now and then observed. The growing ledge may occasionally so encroach from all sides upon the position of a parietal oscula, that there finally arises a narrow canal opening externally

at some point on the ledge itself and leading internally into the gastral cavity.

The fine *dermal latticework* is scarcely discernible by the naked eye but under a hand-lens may be seen to extend all over the external surface, except on the thin iris-like oscular membrane. The nodes of the delicate lattice generally appear as minute whitish spots. Through the layer are everywhere to be seen, in varying degrees of distinctness, the entrances into the incurrent canals. These are of all sizes under 1 mm. diameter.

A *cuff* is usually more or less distinctly present. In several specimens, it was plainly developed for only a portion of the sieve-plate circumference and merely suggested for the rest. It is as a rule directed obliquely upwards; exceptionally, however, it becomes nearly horizontal. Its free edge is always uneven and and occasionally even deeply indented, thus giving unequal breadth to the cuff in different parts. Measured on the upper surface, the breadth may be as much as 10 mm., but generally is much less. On the lower side, the cuff is joined by the parietal ledges which run between the last oscula at this end and are here comparatively low. Besides being somewhat thinner, the cuff differs from the average crests of the parietal ledge in being rather sharp-edged instead of being rounded, and in showing a fringe of fine, inconspicuous marginalia, projecting to a length of less than 1 mm. But this difference is of no essential importance, since certain parietal crests have been occasionally found having characteristics exactly like those of the cuff.

The *sieve-plate* may show in some cases a convexity nearly

equal to that of an ordinary watch-glass. More frequently it presents a stronger arching, being often of the shape of a hemispherical vault. The meshes are smaller than in *E. imperialis* and never exceed 4 mm. in their greatest width; they have mostly a shape varying from oval to triangular or polygonal, the corners in the latter cases being invariably rounded. The beams are comparatively strong-looking and are distinctly laterally compressed like those of *E. aspergillum* or *E. oweni*. Seen from above, the majority are less than 1 mm. or even half a millimeter in width; but the same beams, when seen from the sides, may be considerably wider, up to nearly 2 mm. in the case of a strong beam. Towards the nodes, as seen from above, the beams either maintain their width uniformly or broaden so as to form a more or less distinct nodal thickening. Occasionally a beam or a node is so broad (up to 3 mm.) as to deserve to be called plate-like. A distinction of the meshes into the greater and the lesser—the former bounded by wider beams and containing a number of the latter—can not be made in the present species.

The surface of the sieve-plate beams is on the external side close-grained and compact-looking, while on the inner side are seen small excurrent openings scattered between separate strands of fibers.

The lower end of the sponge-body (Pl. IV, fig. 5) is likewise closed by a perforated plate, the *bottom-plate* (see p. 40). Though often found in a damaged condition, the occurrence of this plate seems to be constant in the present species. It is a direct continuation of the lateral parietes; thin, measuring not more than about $1^1/_2$ mm. in thickness; tolerably even on both surfaces; and nearly flat or outwardly convex. The skeletal framework

of the lateral wall ceases to exist just around the bottom-plate, so that the texture of the latter is entirely soft, being nearly exactly like that of the parietal ledges. There can be no doubt whatever that the round perforations of the plate are morphologically and functionally the same as the parietal oscula or the sieve-plate meshes. In the main middle portion of the bottom-plate, the oscula are irregularly scattered, while in the periphery directly adjoining the last circular beam of the skeletal framework, they are somewhat larger and more closely set, leaving between them narrow beams by which the more central portion of the plate is attached to the lateral wall. The plate therefore most easily breaks off at these weak points in the periphery. The internal surface shows a number of small excurrent apertures; the external surface appears essentially the same as that of the lateral wall.

The bundles of basal *anchoring spicules* emerge from the lateral wall in a circle near the juncture of the latter with the bottom-plate, soon to form a soft and silky basal tuft in the usual manner. Since now, as already noticed, the lower end of the sponge-body is compressed, the inverted hollow cone formed by the basal spicules immediately after their emanation from the wall, is likewise laterally flattened. More properly speaking, this primal portion of the basal tuft is wedge-like in shape. It is perfectly free of foreign objects interlocked among the fibers and I have no doubt that this portion stands above and clear of the surface of the substratum. Now, the compressed state of the tuft just before it strikes root into the substratum, would give to the sponge a greater freedom for swaying in one direction than in any other. I think it quite likely that this circumstance stands in a definite

relation to the prevailing direction of the movement of the surrounding medium. The lateral compression of the body, especially at the base, in so many other Lyssacine Hexactinellids may possibly fall under the same category of phenomena.

For the rest the basal tuft penetrates into the sea-bottom and represents an irregular, elongate and often bulky mass, inclosing a fair sample of the bottom (fragments of sponges, Bryozoa, Mollusca, &c.; sand and pebbles). The lump is frequently much longer than the sponge-body proper. I can not tell whether or not, it is simply due to the loose character of the substratum in this case, that such a large basal mass is taken up with the sponge.

The appearance of the wall on the gastral side (Pl. IV, fig. 4) is essentially the same as in other *Euplectella*. The transverse ridges are on the whole well set apart from one another, notwithstanding the frequent occurrence of anastomoses by means of obliquely running ridges. The longitudinal ridges show less regularity of arrangement in so far as they often run in pairs unusually close together. Such double ridges occur without definiteness as to their position. The two may remain nearly unchanged in relative position throughout their entire length; at other times they may in their course either fuse into one or diverge into two indubitably distinct ridges.

Close to their juncture with the sieve-plate, the transverse ridges are usually scarcely recognizable as such. We rather see here only obliquely and longitudinally running ridges or beams, which above pass directly into the formation of sieve-plate beams (upper part of fig. 4).

The beams of the skeletal framework, which form all the

ridges seen on the gastral surface, are more often composed of several strands of fibers in close union, than of a single compact strand. With respect to the relation between the different systems of skeletal beams, it may here be mentioned that the oblique beams very frequently blend into the transverse as well as into the longitudinal beams, besides entering into all sorts of relations at the points where they intersect these. Some oblique beams are plainly seen to pass between these two systems; some to penetrate through their separate strands or fibers; and others to pass over even to the inside of the transverse or to the outside of the longitudinal beams. In short, the oblique system of skeletal beams may be said to permeate the two other systems rather than to occupy an intermediate position. As a separate system, the oblique beams in *E. marshalli* are apparently in a state of less differentiation than in many other species, e. g., *E. imperialis*. I shall have later to return to the adult skeletal beams when I come to treat of quite young specimens.

The rectangular meshes, formed by intersecting transverse and longitudinal ridges on the gastral surface, are either quadratic or somewhat elongated in the longitudinal direction. They are largest at the most out-bulged portion of the sponge, where they may measure 4-6 mm. in length of sides in large specimens. In conformity with the irregular distribution of the parietal oscula as seen from the outside, no definite rule can be laid down with regard to the relative distribution of the so-called interstitial meshes and those perforated by the oscula. Not infrequently, either kind of mesh may be seen several in succession transversely, longitudinally or obliquely in one direction or the other.

Spiculation.

E. Marshalli is one of those species whose spicules remain all perfectly free, never and nowhere becoming soldered together by synapticulæ. I am inclined to bring this in correlation with the fact that no point of the living parts is in direct contact with the substratum (see p. 45).

The composition of the *parenchymalia* is essentially the same as that which I have described for *E. imperialis*. The large or medium-sized stauractin *principalia*, common to the transverse and the longitudinal beams of the skeletal framework, have slender tapering rays which are subterminally roughened and generally conically pointed at the ends. The rays may be 110 μ thick near the spicular center, the longitudinal axis being 45 mm. or more and the transverse 20 mm. in length. The two rays constituting the former axis are usually of unequal length but form a straight line, while those of the latter are symmetrical in length and form with each other an obtuse angle open towards the axis of the body, or are at any rate bent to conform with the curvature of the circumference. Toward either end of the sponge, the stauractins become smaller, the rays at the same time approximating in their relative length.

The *comitalia* to the above principalia are, as usual, mostly thetactins; occasionally also hexactins, paratetractins or pentactins, and rarely diactins. In all these, the rays in an axis, which runs along with the principalia, are greatly prolonged (up to 2 mm. or more in axial length) in excess over the remaining ray or rays which spring out more or less vertically from the beams. The diactin comitalia have the center marked by an

annular swelling or by cruciately disposed knob-like rudiments of the suppressed rays. The prolonged comital rays are mostly under 25 μ in breadth near the center; they taper outwards, thence to maintain a nearly uniformly thick, filamentous caliber to the end, which is rounded or conically pointed and subterminally rough-surfaced.

Scattered here and there among the fibers of the beams in question, I have on certain occasions found small hexactins, pentactins, stauractins and such like, whose short rays made them appear to be somewhat distinct from the other much elongated elements but which are probably to be classed together with these simply as cases of arrested development.

The oblique beams of the skeleton show a similar composition save the absence of stauractin-principalia. Slender thetactins and paratetractins predominate among their elements; frequently intermixed with these are pentactins and hexactins of moderate strength. Just the same elements constitute the parenchymalia of the flake-tissue, in which they are arranged either loosely or in small bundles. A number of the latter in radial and rafter-like arrangement serve to support the parietal ledge, similarly as described by F. E. Schulze ('87) for *E. aspergillum*.

As a category of spicules closely associated with parenchymalia must be considered the *prostal oxydiactins*, which, occurring in comitalia-like bundles around the distal rays of certain dermalia, cause inconspicuous bristle-like projections along the edge of the cuff and of certain parietal crests. The same sort of spicules is also known in *E. imperialis*, *E. nodosa*, &c. (p. 72). In the present species, the oxydiactins in question are small, being at most about 1 mm. long and not exceeding 8 μ in thick-

ness near the center. They are smooth all over but usually show a gentle annular swelling at the center. They are not to to be confounded with the rhaphides (Pl. V, fig. 36) which are similarly grouped around the distal rays of dermalia but are of a quite different origin and character.

The *oscularia* (Pl. IV, fig. 27) are of quite varied shapes and sizes. The more common forms are diactins (compass-needle-like, with either two oppositely or four cruciately disposed central knobs), thetactins, stauractins, paratetractins and pentactins. Rays smooth, moderately thick, reaching 330 μ or more in length and 35 μ in thickness near the center. It is difficult to point out which of the above mentioned forms is the predominant. The diactins are more commonly located near the edge of the oscular membrane; some of the thetactin and pentactin forms stand intermediate respectively to the parenchymalia and the gastralia in points of general appearance and mode of occurrence. For differences from the oscularia of *E. imperialis* and *E. oweni*, compare fig. 17, Pl. II, with fig. 10, Pl. VI.

The *basalia* (Pl. IV, fig. 26) have a broadly miter-shaped anchor-head, measuring 90-110 μ across from tip to tip of the oppositely standing teeth. The latter are strongly developed and are 5 or 6, sometimes 7, in number. The apex of the head is either rounded or pointed as in a Gothic arch. The shaft is about 26 μ thick at the point of its origin from the head, whence it gradually narrows above until at a short distance above the position of the axial cross (which lies nearly 150 μ away from the origin of the shaft), the thickness measures not more than 12 μ. It then begins to thicken again, up to the maximum

thickness of 35 μ. The axial cross has been determined to be (always?) simple, that is to say, having a single cross-piece. Closely above the position of the cross are the first barb-like spines, of which there are usually two opposite each other, or sometimes more than two in a whorl. The rest of the spines are arranged along the shaft in an approximately regular spiral row.

The bundles of basal spicules, so long as they run alongside the skeletal tube, are as a rule entirely covered by the flake-tissues—not exposed by the falling off of the latter. Superiorly they extend in the wall for fully two-thirds of the body-length.

The *dermalia* (Pl. IV, figs. 16, 28; Pl. V, fig. 36)—sword-like hexactins as usual—have rays which are on an average 10 μ thick near the center and taper out to more or less sharply pointed ends. In certain specimens, however, the hilt-ray was often bluntly rounded at the end, but never showing a swelling in its course. The length of the hilt-ray is 130-170 μ, on an average 150 μ; blade-ray generally more than 3 times as long, up to 700 μ; guard-rays somewhat longer than the hilt-ray. These form the well-known dermal latticework, the meshes of which are about 200 μ in width. Both the hilt and the blade rays possess for the greater part of their length sparingly distributed, minute tubercles. The guard-rays are nearly quite smooth all over.

A specially large size is attained by those dermalia which are situated along the free edge of the cuff and of certain parietal crests and whose hilt-ray stands in association with the prostal oxydiactins already described. These dermalia are frequently nearly 2 mm. long, the hilt-ray measuring 300-400 μ in length. The rays may be twice as thick as in the ordinary dermalia of the general surface.

The *gastralia*—slender-rayed pentactins of medium size—are quite like the ordinary dermalia. The paratangential rays, 140-200 μ long, are often bent and of unequal length in the same spicule. The distad directed, unpaired ray is straight and frequently more than thrice as long. The gastralia are rather isolated in their distribution, especially so on the inner surface of the excurrent canals, in which they receive the name of *canalaria* (Pl. IV, fig. 28).

The *floricomes* (Pl. IV, fig. 10) are very common, but less so in the elevated regions of the parietal ledges than in more depressed parts. They occur both subdermally and at the apex of dermal hilt-rays. Diameter 70-80 μ; principal rays under 6 μ in length as measured from the central point of the rosette. The number of terminals in a perianth varies from 9 to 12. Marginal teeth of the terminal plate are well developed; 3-5 in number.

The *oxyhexasters* (Pl. IV, fig. 17) are much less numerous than the floricome. They occur both subdermally and subgastrally. Occasionally I have met with some lying outside the layer of dermal paratangentials. They are least numerous, even rare, in the ledges. At certain other places, as, e.g., near the parietal oscula or in the subgastral region, they are tolerably common. Diameter 75-83 μ. Each short and thick principal ray bears 3 or 4, sometimes only 2, diverging terminals. The latter moderately strong, smooth and nearly straight or only slightly bent.

The *graphiocomes* (Pl. IV, fig. 19; see also fig. 28) are probably the commonest of all the hexasters. They occur in all

parts of the sponge but are confined to the external trabecular region under the layer of dermal paratangentials. The principal rays (fig. 20) are about $7^1/_2\,\mu$ long as measured from the spicular center; the surface shows minute tubercles; the disc at their distal end is, on the outer surface, densely beset with the thickened bases of rhaphidial terminals. When the latter fall off, as they seem to do by a normal physiological process, the bases remain to the disc as small spiny processes (fig. 20). It is of very frequent occurrence that one meets with the relics of graphiocomes after the complete or partial loss of the terminals or rhaphides. These attain a length of $115\,\mu$ when fully developed.

Free *rhaphides* are found among the trabeculæ in considerable quantities, either irregularly scattered or still grouped in sheaves and often under such circumstances of relative position to graphiocome-relics as put the original connection of both beyond the reach of doubt. They seem to be moved on towards the surface, becoming on the way so directed as to point outwards with one end, and finally to mostly arrange themselves in a bundle-like manner along and around each hilt-ray of the dermalia (Pl. V, fig. 36). In no other species that I have studied were the rhaphides so constant or abundant in the position just mentioned. The commonness, even in old individuals, of the source of rhaphides, i.e., the graphiocome, indicates that these fine needle-like spicules are being constantly thrown out from the sponge surface, in all probability as a sort of defensive missile.

The account of developmental facts with regard to the above three kinds hexasters, I will defer until I shall have completed the histology of the soft parts.

As the fourth kind of hexasters present in *E. marshalli*, I

should here mention the rosette I have figured on Pl. IV, fig. 21. It occurs quite rarely and solitarily but apparently is constant alike in both young and old specimens. So far as I know, it seems to be peculiar to the present species. The diameter measures 40-45 μ. The principal rays resemble those of graphiocomes; the discs at their ends are lens-like or prominently convex on the outer surface. The terminals are exceedingly fine, about as long as or somewhat longer than the principals; they are pointed at the outer end and arise closely together from all parts of the outer disc-surface. The peripherally situated terminals in each tuft are slightly but distinctly flaring, so that the tuft may be said to be campanulate. The entire rosette looks not unlike a plumicome or graphiocome in an early stage of its development in which the terminals are still very short. However, it differs from the former in that the terminals in a tuft are all nearly equally long; and from the latter it differs in having the terminal tuft expanded into a bell-like form. The rosette above described is found only at such long intervals that it requires a close study of preparations in order to come across one.

The spiculation of the *sieve-plate* deserves special notice in respect of a few points. Unlike *E. imperialis* and many other species, the predominant elements of the sieve-plate parenchymalia are thetactins, instead of diactins. The thetactins furnish both the principalia and the accessoria, the latter also containing elongate hexactins, pentactins, &c. The parenchymalia, in forming the beams, are disposed in several loose or compact strands, between which are left sufficient spaces for the location of the much folded chamber-layer and of small excurrent canals opening on the gastral side. All of the four kinds of rosettes found in

the lateral wall are present in about the same numerical proportion. Both the dermalia and the gastralia are almost exactly like those of the lateral wall.

The *bottom-plate* is spiculated in essentially the same manner as the lateral wall, except that here the parenchymalia, which are again mostly thetactins with slender rays, run almost always singly and in various directions, combining but seldom into loose fascicles. The plate is therefore weakly supported and easily breaks down. The dermalia and the gastralia differ in no way from those of the lateral wall. The former are irregularly arranged instead of forming a regularly meshed latticework.

Young Specimens.

I have before called attention to points by which the early postembryonal stages of *E. imperialis* and *E. marshalli*, though closely alike in general outward appearance, may be distinguished (p. 79). Now, from Dōketsba I have not a small number of young *Euplectella* in various stages of growth, all of which I do not hesitate to refer to the present species. Apart from the circumstances that no other species of *Euplectella* is known to occur in that locality and that the specimens in question form an uninterrupted series leading up to such as have the characteristics of *E. marshalli* fully and unmistakably developed, I have sought to establish the correctness of my identification by ascertaining the size of the floricome in each specimen. This, in all cases with which we are now concerned, has been found not to exceed 80 μ in diameter, exactly as it should not if the specimens were *E. marshalli*; whereas, in all those young specimens of similar size, which I have referred to *E. imperialis*, the diameter reached 91 μ.

In all the young specimens the tubular body has in general a spindle-like ventricose shape (Pl. IV, figs. 6-9). At first the ventricosity is situated at about the middle of the body ; it may however soon be brought to a somewhat lower level, probably because the growth in length at the upper end is relatively more rapid than the general increase in circumference. The lower end is contracted and blindly closed at its juncture with the yet weakly developed basal tuft. The upper end is truncated unless the more or less convexly arched sieve-plate, which is very delicate and therefore easily detached in the early stage of its formation, is preserved intact.

The smallest specimen I have had was only 18 mm. long (exclusive of the basal tuft), 7 mm. broad at the middle and 2 mm. wide across the round opening at the superior end. Three other very small specimens measured 20-23 mm. in length, 7-9 mm. in greatest breadth and $2^1/_2$-4 mm. across the superior truncated end. One of these specimens is shown in natural size on Pl. IV, fig. 6. The entire external surface is on the whole even and covered over uninterruptedly by the dermal layer. A few isolated gaps seen in the superficial tissue proved on close observation to be rents due to laceration. Unless the wall has become untransparent by drying up, the longitudinal beams of the skeleton can be made out to a greater or less extent, while the transverse beams are quite indistinct. The canals in the wall appear to the naked eye as darkish spots, which become smaller toward either end of the body and finally are hardly visible, so that the wall tissue at the ends assumes a uniformly whitish appearance. Of the delicate sieve-plate, which must have been present at the open upper end but which seems to have been lost, I shall speak further on.

A very important feature in all the little specimens under consideration is the total absence of parietal oscula. These are at any rate macroscopically still unopened. However, it can easily be demonstrated under the microscope that there exist in the wall, especially at the bulged middle portion of the body, certain canals or niches which, like the typical excurrent canals, extend with a free lumen from the gastral cavity, but, which unlike them, are not blindly capped by the chamber-layer at the outer end. There is, at the spots in question, a gap in the chamber-layer and here the gastral cavity stands in free communication with the outer world through the narrow lacunæ between the trabeculæ. At the spots a condition obtains quite similar to that figured by F. E. SCHULZE in the Challenger-Report ('87, Pl. LIII, fig. 5) for young *Lanuginella pupa* at the part where the oscular area should later develop itself. I suppose that functionally the spots in the above described condition are already playing the rôle of parietal oscula. The latter will become definitely established, if only the trabeculæ and the dermal skeleton give way for a freer passage than before, in order to meet the requirement of an ever increasing quantity of outflowing water. I find the above idea concerning the formation of parietal oscula perfectly corroborated by my observations on the growing parts of larger specimens.

The character of the wall in quite young *Euplectella* might then be said to agree essentially with that of *Holascus* (see p. 39). The only important difference between the two genera mentioned seems to consist in the development or non-development of parietal oscula. The well-developed external ledges of *Euplectella*, as also of *Regadrella*, are apparently the outcome of the excessive

thickening of the wall in the presence of interruptions in the form of parietal oscula.

In somewhat older specimens of 32-35 mm. length and 10-11 mm. greatest breadth, there already exist a varying number of parietal oscula, which are still very small but yet visible as distinct openings. They first break through in the bulged middle portion of the body. Nearer the ends but especially in the upper region, they are still in a state of incipient formation, being covered over by the dermal layer. The wall-tissue between the open parietal oscula has begun to swell out gently as the first step in the formation of the ledges, which henceforth become more and more conspicuous as the sponge advances in growth. Fig. 7, Pl. IV, shows the skeleton of an individual of the size in question, from which the loose tissues have been rubbed off.

As representatives of still larger young specimens, whose appearance has notably approached that of adults, will serve the two shown in figs. 8 and 9, Pl. IV. In the smaller specimen (fig. 8) the parietal oscula, though yet small in size, are already numerously present. They may be said to be situated at the bottom of shallow dimple-like depressions of the external surface. In many of the depressions, however, the oscula have not yet opened through. In the larger specimen (fig. 9), the external elevations between the parietal oscula have definitely taken the form of an irregular network of ridges or ledges, which are most pronounced on the broadest middle portion of the body. Each depressed mesh generally contains only a single oscular opening, but sometimes there are more in an indefinite arrangement. The largest of the openings are still under 1 mm. in diameter. They occur

on the greater part of the body including the lower end. Toward the upper end, they gradually become smaller, while at the same time the external depressions closed at the bottom become more and more frequent. In some of the depressions the oscula are found in the first stage of breaking through. The ledges become superiorly less and less prominent, until finally at a short distance before reaching the superior edge of the lateral wall they cease altogether to exist. So that, there remains at this terminal region an even-surfaced, unperforated zone of nearly uniformly compact appearance,—a zone retaining the characteristics of the wall in a much earlier developmental stage.

Such a plain-looking marginal zone is observable up to a stage when the sponge measures about 70 or 80 mm. in length. So long as it persists and also for some time after it has become perforated by newly formed parietal oscula, the soft cuff proper is slightly or not at all developed. This develops distinctly after the ledge formation, which follows that of the parietal oscula, has extended to the uppermost rim of the lateral wall. Nevertheless, I find this rim in all young specimens before they acquire the true cuff not quite thin and sharp, but possessing a firm narrow edge squarely cut off (see the upper end of fig. 7). This is due to the fact that many of the slender parenchymal spicules composing the longitudinal skeletal beams and coming up to the rim are exceedingly elongated sword-like hexactins, of which the five relatively very short rays, corresponding to the hilt and the guard, are situated in a row at the very edge of the lateral wall. Strange to say, I have not succeeded in finding the same parenchymal hexactins in full-sized specimens. This may however be explained by assuming that the said hexactins after a certain period neither grow in size nor increase in number, and

consequently become so concealed among the crowd of other spicules more lately developed that they easily elude detection. Further it may be that, as the sponge grows in length at the superior end, the parenchymalia once occupying the edge may be left behind, instead of being shifted along and in perpetual connection with the edge.

As to the *sieve-plate*, in most specimens under 50 mm. length, I find it entirely or almost entirely lost, so that the gastral cavity opens above by a wide circular aperture. The beams of the plate in such small individuals are so thin, soft and excessively frail as to break off on the slightest provocation. I have known them to succumb to the rush of water as the freshly caught specimens were being picked out of the sea. At other times I have seen the air-bubble in the gastral cavity or the motion of alcohol into which fresh specimens were thrown, disturb or destroy the sieve-plate. In many cases, the soft and delicate beams were severed clean off from the comparatively firm rim of the wall, leaving no trace of the sieve-plate visible to the naked eye; in some other cases, they left behind as relics a greater or less amount of shreds attached to the rim. In the specimens figured in figs. 6-8, Pl. IV, the sieve-plate was entirely gone. Only in two specimens out of several measuring under 50 mm. in length, do I find the plate nearly completely preserved by some fortunate circumstance. I have given double-sized sketches of both these cases in fig. 15 *a* & *b*. In the one specimen (39 mm. long), the plate is scarcely or but slightly arched; the meshes are ten in number. In the other specimen (48 mm. long), it is convex, like a watch-glass; the number of meshes exceeds 10 by a few.

The beams are at places about $^1/_3$ mm. broad, but for the most part are exceedingly fine.

Specimens of over 60 mm. in length of body show a well arched sieve-plate, which is of sufficient strength to remain intact in most cases. For instance, the specimen of fig. 9 (63 mm. long) has a complete, vault-like sieve-plate with about 35 meshes.

As to spiculation of young specimens, I have, in the first place, subjected a portion of the youngest specimen I have had (18 mm. long) to a careful examination. The dermalia were found to be sword-like hexactins like those of adults. I mention this because in *Regadrella okinoseana* I have found the dermalia in quite early postembryonal stages to consist of pentactins which are later replaced by hexactins (see under that species). In the absence of parietal oscula, the oscularia are certainly not developed. It is noteworthy that, although both floricomes and graphiocomes were common and even that rare form of hexasters shown in fig. 21, Pl. IV, was met with in a few instances, yet I failed to discover a single oxyhexaster in that little specimen. The floricome (62-72 μ dia.) was on the average smaller and its terminals somewhat more slender than in adult individuals. Rhaphides detached from the graphiocome were already present in the superficial region, though by no means yet in great profusion.

Of the spiculation in other young specimens I will make only the following remark. The oxyhexaster was sought in vain or was met with exceedingly rarely in preparations made from several individuals under 60 mm. in length of body. From about the period of the body-length just mentioned and onward, the oxyhexaster begins to be constantly seen, though not in abun-

dance at first. It occurs, for instance, in the specimen of fig. 9, in some numbers. The oscularia also begin at about the same time to differentiate around the oldest formed parietal oscula. Most of them are at first scarcely distinguishable from the gastralia. Essentially the same spicular elements as in adults occur in the delicate sieve-plate, though much more sparingly and in looser arrangement.

Concerning the separate beams of the skeletal tube, I may mention that throughout the body of quite young specimens, as in the growing upper end of older specimens, the oblique systems are wanting or at most are represented by isolated fibers. Of the two other systems, the beams of the longitudinal are always somewhat thicker than those of the transverse (fig. 7). This is at any rate partially due to the presence of basal needles in apposition with the former.

In order to obtain insight into the mode of development of the skeletal tube, I have counted the number of the transverse and longitudinal beams in a series of not only variously sized young specimens but also of those which might well be considered to be nearly or quite full-grown. The list is given on the following page; in it the specimens are arranged in the ascending order of their body-length, beginning with the shortest.

I must say that, notwithstanding my efforts to be as exact as possible in counting, the figures in the columns I and II of the annexed table, can represent only approximately the numbers of the beams they stand for. Absolute precision in this matter can not be expected owing to the frequent occurrence, especially in the longitudinal system, of beams of such a character as makes it impossible to decide whether they are to be reckoned in any case as single beams or not. This ambiguity evidently stands in

Number of transverse and longitudinal skeletal beams in variously sized E. marshalli.

No.	Size of Specimens.		I.	II.
	Length of body (excl. of sieve-plate and basal tuft).	Mean diameter of gastral cavity at middle of body.	Number of transverse beams.	Number of longitudinal beams (at middle of body).
	mm.	mm.		
1	20	6	?	26
2	22	5.5	35	27
3	23	7	30+	28
4	31	8	39	25
5	32	7	35	27
6	33	7	32	26
7	34	8	32	26
8	34	8	38	33
9	38	7	41	25
10	42	6	36	?
11	52	10	47	32
12	58	12	39	35
13	66	16	62	28
14	74	14	44	29
15	75	11	70	33
16	82	18	43	26
17	88	20	52	38
18	109	20	50	30
19	110	27	44	37
20	116	33	38	43
21	116	38	36	38
22	120	26	36	37
23	122	32	?	43
24	127	52	28	35
25	130	36	38	43
26	140	30	45	44
27	140	36	51	34
28	143	36	47	39
29	155	40	42	45
30	182	44	40	44

relation to their mode of multiplying themselves, which is by splitting and gradual separation into two of an originally single beam, as was first shown by F. E. SCHULZE ('95, p. 24). Moreover, the continually recurring rise and fall in the value of figures in the two columns make it manifest that the number of beams in both systems, but especially in the transverse, is subject to certain, often very considerable, variations according to individuals. Under such circumstances there is but little prospect of accurate inductive inferences being made from the annexed table, unless it be known what allowances to make for variations in individual cases, which is certainly not known. Nevertheless, it seems to me that the general trend of figures in columns I and II is anticipated by certain facts observed in the manner of the arrangement of the beams.

Firstly as regards the transverse system, it may be considered as a general rule that the distance between each two beams is widest where the sponge-body shows greatest ventricosity, i. e., at or somewhat below the middle of its length. Toward the base, the interval usually lessens somewhat or may remain nearly the same. So also toward the upper end in old specimens. In young specimens, on the other hand, it grows superiorly on the whole gradually and continually less and less, until, at the marginal zone close to the juncture with the sieve-plate, a condition is reached which is strikingly different according as the new-formation of transverse beams is taking place or not. It is in that zone of comparatively small specimens only,—say of a length under 70 mm. or 80 mm., at any rate of not over 100 mm.,—that there exist indications of the transverse beams undergoing active multiplication. I have before called attention to the primitive character of this outwardly smooth marginal zone, which is yet

unperforated by the parietal oscula (p. 107). Here a number of fine circular bands, composed of yet weakly developed parenchymal spicules, lie most closely together, attesting their recent formation as was pointed out by F. E. SCHULZE ('95, p. 25). On the other hand, specimens of over, say, 100 or 120 mm. length, no longer show this peculiar characteristic in the corresponding region, although this may still be somewhat backward in the general development of its parts. The last transverse beams at this end of the sponge stand more or less distinctly apart, or at any rate never so close together as in an earlier period of growth, and the very last beam is commonly separated from the superior rim of the lateral wall by a space which is traversed only by oblique or longitudinal beams that directly pass above into the sieve-plate beams. Parietal oscula are now met with right up to the border of the sieve-plate. (See upper part of fig. 4, Pl. IV). To all appearances, then, the marginal region, as also the parts further below, is no longer giving rise to new transverse beams, although the possibility of, so to speak, sporadic new-formations can not be altogether excluded. To sum up: the transverse beams develop to their maximum number before the sponge-body has grown to a length of about 100 mm. During its subsequent growth, the beams should go only wider and wider apart from one another, their number remaining practically stationary or nearly so.

Turning now to column I of the table, the above fact seems foreshadowed in that some of the highest figures are already met with before the specimens attain a length of 100 mm. The fall of figures for larger specimens, observable in the table, is probably to be explained as mainly due to individual circumstances and not to actual decrease in number. However, I am inclined

to think that the latter process may at times possibly take place, some of the originally transverse beams becoming transposed into the oblique.

Secondly with respect to the longitudinal system (column II), there is observable a general rise in the value of figures from top to bottom of the column, indicating a continual addition to its beams along with the growth of the sponge. This corresponds with the fact that even in the oldest specimens there exist here and there such longitudinal beams as seem to represent different stages of splitting lengthwise and separating into two.

If now the transverse beams should cease to multiply at an early period while the longitudinal persist in multiplying, the numerical proportion of both in young specimens must be quite different from that in old specimens. This is likely the explanation of the fact to be noticed in the table that, while down to the specimen of 110 mm. length (No. 19) the excess of difference between the numbers of the two kinds of beams in each specimen stands on the side of the transverse system (I), the case is reversed in most of the remaining larger specimens.

For *E. simplex*, F. E. SCHULZE ('95, p. 23), by counting and comparing the number of the two kinds of skeletal beams in half a dozen young specimens of various size, has reached the conclusion that, during the growth of the sponge, the transverse beams increase considerably in number while the longitudinal do so to but an insignificant degree. To wit: the smallest specimen, 35 mm. long, had 25 transverse and 28 longitudinal beams against 40 and 30 respectively of a specimen 110 mm. long. In order to see how far SCHULZE's above conclusion can be verified with *E. marshalli*, it would be necessary to take into consideration only those young specimens of that species in which both

systems are actively increasing the number of their beams. As such may be regarded Nos. 1-17, given in the table (say, specimens ranging from 20 to 90 mm. in length). From the data afforded, I think it safe to give the range of numerical increase, in these specimens, of the transverse beams as from 32 to 52 or even up to great deal more (say, an increase of 20 and *over*), and of the longitudinal beams as from 25 to 38 (an increase of 13, which is likely about the maximum limit). It can not then be gainsaid that, during the life-period represented by these specimens, the former increase in number with greater rapidity than the latter,—a fact which, so far as it goes, conforms to the general tenor of SCHULZE's statement.

Should however a young specimen of *E. marshalli* be brought into direct comparison with an old one as regards the points in question, one may be misled into quite different inferences. For instance, by comparing specimen No. 2 (of the table) with No. 28, the appearance is that the rates of increase of the two kinds of beams have kept pace together, both showing alike an increase of 12. It may even be found, as e.g. by comparing Nos. 2 and 30, that the longitudinal beams have increased far more than the transverse. It is plain that these appearances are due to the fact that the longitudinal beams have continued to multiply themselves after the transverse have ceased to do so.

I think what has been said above concerning the increase of the skeletal beams is, in the main, applicable to all species, or at least to those in which the synapticular fusion of spicules never takes place. In *E. imperialis*, which is one of the species with a partially rigid skeletal framework, the multiplication of the beams is made impossible as soon as the amalgamation of their elements sets in and so far as this extends in the lower

part of the body. At the upper end, however, it still continues to go on (cfr. pp. 68, 82). Here, the new-formation of the transverse beams is carried on apparently to a much later life-period (as judged by the size) than in *E. marshalli*, but it likewise seems to stop some time before that of the longitudinal beams is brought to a completion or this end of the body attains its maximum girth.

Soft Parts.

As the most readily obtainable Hexactinellid in the Sagami Sea, *E. marshalli* has supplied me with my best opportunities for the study of the soft parts. The following account, in the absence of special mention to the contrary, refers to that species, although in the main it may be regarded as applicable to a wider circle of forms and even to the Hexactinellida in general. As has been stated by F. E. Schulze ('87, p. 23), the histological structure is so uniform throughout the entire group, that the modifications to be noted are hardly of an important character.

Let it at once be stated that as regards the general arrangement of the soft parts, the facts before known through the investigations of F. E. Schulze ('80, '87, '99*a*, 19'*a*), so far as they go, have found essential confirmation in the results of my own observations, though in respect of certain important points relating to the finer structure, my results stand irreconcilably at variance with his.

The sponge-wall, being composed of the soft parts and the spicules, is, as has been observed by F. E. Schulze, remarkable for the exceedingly cavernous character of its structure. It is thoroughly penetrated by intercommunicating lacunar cavities and passages, across which, it may be said, the soft parts stretch

themselves only in the form either of cobweb-like or film-like trabeculæ or of a cribellate membrane (chamber-wall, membrana reticularis). All the soft parts, if put together apart by themselves, would make up but a comparatively small volume falling considerably below the mass of the spicules and would appear almost insignificant in proportion to the space occupied by the entire sponge in its undisturbed state.

General arrangement of the soft parts and their relation to the spicules.—The flagellated chambers, whose structure will be specially dealt with in the next paragraph, are, as is well known, arranged side by side in a single layer, the chamber-layer (Pl. IV, fig. 28, *ch. l.*), which separates the outer from the inner trabecular layer of the sponge-wall (see p. 41). As is further known, the chamber-layer (which is not to be confounded with the chamber-wall) forms in the choanosome numerous, outwardly directed protuberances or evaginations, which are proximally open and distally blindly closed. The evaginations are of various sizes and of great complexity of form. While some are quite small and simple, others, especially those that extend into the parietal ledge and correspond in position with the larger excurrent canals, may be of very considerable length and caliber, and moreover bear on their sides a greater or less number of secondary evaginations, which may again repeat the branching process. The final branches belonging to different systems of the evaginations remain separate, although the possibility of their coming into an intercommunicating anastomosis under exceptional circumstances can not be excluded.

The chamber-layer may then be considered as forming by itself a voluminous mass with its complex system of evaginated

protuberances. Assuming that mass to be free of the trabeculæ and the spicules, with which it in reality is connected both externally and internally in making up the choanosome, there should lead out proximad from it numerous, separately opening tubular passages, not unlike the radial tubes of Sycons and which give molding to the excurrent canals of the choanosome. Externally, between and around the contiguous, irregularly shaped protuberances, there should exist, this time not tubular passages, but an exceedingly intricate and continuous interspace, which, like the intercanals of Sycons, forms a part of the general system of incurrent spaces. Along the course of the incurrent canals penetrating into the choanosome, the interspace just mentioned is more or less wide; at most other places, especially in the deeper region, it is quite narrow and often exceedingly compressed in that the external surfaces of chambers, belonging either to the same or different protuberances, come nearly or even quite into contact with one another.

The trabeculæ in their relation to the above mass of the chamber-layer show in the original primitive condition the following arrangement: The outer trabecular system forms a continuous superficial layer, covering over the outer ends of the chamber-layer evaginations and thence extends alike into all parts of the afferent interspace between the latter; similarly, the inner trabecular system continuously covers the inner surface of the sponge-wall and also pervades all the efferent hollows of the evaginated chamber-layer. In short, we may consider the entire thickness of the sponge-wall as consisting of a nearly uniform network of thin trabeculæ which keep the folded chamber-layer suspended midway between the two surfaces of the wall. Such a comparatively simple arrangement of the soft parts is always

met with in that region of the body, especially in very young specimens, in which the wall is still thin and backward in the development of its parts.

As is easily conceivable, the increase of the wall in thickness and of the chamber-layer in the extent and complexity of its evaginations, puts into requisition a freer passage than before for the accelerated in-flow and out-flow of water, and thus arise the incurrent and the excurrent canals. Both of these systems of canals are simply relatively larger intertrabecular spaces which, in the form of elongated passages, penetrate more or less deeply into the choanosome. The canals are therefore, at the commencement of their formation, indistinguishable from ordinary intertrabecular lacunæ. However, after attaining a certain length and caliber, they deserve their name all the more since the lining trabeculæ and certain spicules give to them a more or less definite, though of course much interrupted, septum-like wall.

The excurrent canals (Pl. IV, fig. 28, *ex. c.*) develop each as a direct continuation of the gastral cavity in the axis of the efferent hollows inclosed in the evaginations, before mentioned, of the chamber-layer. They therefore not only correspond in their position with, but also repeat to a great extent the branched configuration, of the latter. The result is that the canals directly communicate with the gastral cavity by widely open orifices, which, unlike those in many species belonging to other families, are not covered over by a continuous endosomal layer supported by a lattice-work of gastralia. The internal trabecular system, forming a thin layer, is directly continued from the gastral surface into the evaginations of the chamber-layer, along the inner surface of these and around the lumen of the excurrent canals. Toward the ultimate branches of the evaginations and

after these have diminished in caliber beyond a certain limit, the canalar lumen disappears or rather becomes indistinguishable from the ordinary intertrabecular lacunæ; in these small branches, as in fact in all evaginations of insignificant dimensions, there persists a primitive condition in that the entire internal space is traversed uninterruptedly by the trabeculæ.

The incurrent canals, it scarcely needs to be specially pointed out, are canalar gaps in the outer trabecular system which pervades the external recesses between the evaginated protuberances of the chamber-layer. They branch during their inward course and may undergo anastomosis with their fellows. They are not always circular in cross-section. In all Hexactinellida they are as a rule smaller but more numerous than the excurrent canals and further unlike these, they never break through externally so as to open directly onto the surface of the sponge-wall. With their outer apertures they join the lacunar spaces in the peripheral trabecular layer, and in fact all the lacunæ and cavities among the trabeculæ form one intercommunicating system on either side of the chamber-layer.

In the peripheral or superficial layer of the external trabecular system just referred to, and which I have before mentioned as continuously covering over the outer ends of the chamber-layer protuberances, there may be distinguished two strata, the outer ectosomal, and the inner subdermal stratum; although it must not be imagined that there always exists any sort of a well-defined demarcation between them. The ectosomal stratum or the *ectosome* is the seat of the latticework of the dermal skeleton and is more or less specialized in consequence of that fact as well as of its most superficial situation. The subdermal stratum is characterized by its relatively more spacious lacunæ

or, what amounts to the same thing, by the comparative sparseness of trabeculæ. The lacunæ in this region are known as the subdermal cavity (Pl. V, fig. 36, *s.c.*). It is from this cavity that the incurrent canals appear to arise, thence to penetrate into the choanosome. Thus, generally speaking, the ectosome extends itself over, and is separated from the choanosome by, the subdermal cavity; the paratangential rays of the dermalia serve as its main support, while the proximal rays of the same as well as a variable quantity of subdermal trabeculæ, effect its connection with the choanosome.

As it presents itself in Euplectellidæ, a considerable thickness is to be ascribed to the ectosome, a fact which is apparently caused by the presence of well-developed distal rays to all the dermalia. Each of the rays just mentioned stretches out the thickness of the ectosome in distal direction so as to form a minute conulus on the external surface of the sponge. The boundary delimiting the ectosome from the underlying subdermal stratum is about as ill-defined as can be. This is in a great measure due to the fact that the subdermal cavity never reaches a prominent degree of development in spaciousness, a peculiarity which stands in correlation both with the fact that numerous proximal rays of the dermalia traverse the region at comparatively short intervals, and also with the small caliber of the incurrent canals. Nevertheless, I think there are grounds for considering that the plane of the dermal latticework (paratangential rays of the dermalia), which in Euplectellidæ lies, as is well known, at a certain distance below the external surface, indicates in a general way the boundary between the two strata. The ectosome is therefore not to be described as a perforated plate-like layer, but, as a part of the general trabecular system, it consists, throughout its

entire thickness, of trabeculæ in an irregular cobweb-like arrangement. On the whole the trabecular cobweb of the ectosome is somewhat denser than in the region below the dermal paratangentials, i. e., in the subdermal region (see Pl. V, fig. 36).

It is important to notice that in the trabecular cobweb of the Euplectellid ectosome in general, the most superficially situated trabeculæ, i. e., those delimiting the sponge periphery from the external world, are often, but not invariably, expanded paratangentially in a film-like or membrane-like manner. The gaps, or the 'pores,' inclosed by such flattened trabeculæ are of a more or less roundish shape and give to the layer itself the appearance of a perforated membrane. This has been called by F. E. SCHULZE the '*dermal membrane*,' and accordingly, the dermalia, as being situated beneath that membrane, have received the name of 'hypodermalia.' Misleading and inappropriate as the latter appellation seems to me to be (see p. 46), the former may with advantage be retained for the purpose of description.

The dermal membrane then forms only a small part of what I have called the ectosome in Euplectellidæ. In other families in which the distal rays of the dermalia do not come into development, the ectosome becomes, as suggested on p. 46, greatly reduced in thickness in that the dermal membrane is brought down to the level of the dermal paratangentials. It is all the thinner because of the subdermal cavity which is generally more spaciously developed in those forms than in Euplectellidæ. The dermal membrane then stands nearly or quite by itself for the soft part of the entire ectosome, in which case the two names may be considered as practically synonymous.

The ectosome of *E. marshalli* in particular requires a few

more words of comment. Noteworthy is the fact that in that species the dermal membrane is scarcely sufficiently developed to deserve being called membranous. In other words, the limiting trabeculæ of the external surface are generally as thin and cobweb-like as, and in no way distinguishable from, those of the deeper parts. The meshes of the surface, or the 'pores,' bounded by such trabeculæ are exceedingly various and irregular in shape and size, just like any intertrabecular lacunæ seen on sections of the sponge-wall. However, occasionally in the spaces between the conuli the limiting trabeculæ are found flattened out into the form of a narrow band or of a nodal expansion (Pl. IV, fig. 23), which, so far as it extends, gives a more or less rounded outline to the meshes bounded by it. In *E. aspergillum*, as described and figured by F. E. SCHULZE, the dermal membrane should be well developed as such; so I have found it likewise in *E. imperialis*, or, at any rate, more extensively membranously formed than in *E. marshalli*. On account of the cobweb-like nature of the entire ectosomal trabeculæ in the last mentioned species, the conuli, when seen from the sides, appear more like the rigging of a schooner's mast (Pl. V, fig. 36) than like conical tents, which they would certainly resemble if only a continuously developed dermal membrane were present.*

* W. MARSHALL ('75, fig. 62) has described and figured the dermal membrane of a young *E. aspergillum* as regularly possessing a single, rather small pore to each quadrate mesh of the dermal latticework. This has been shown by F. E. SCHULZE ('80, p. 666) not to hold true in old specimens, in which the pores had been found to be more numerous and crowded so as to leave less space between them. However, SCHULZE declared himself willing to believe that in the young the pores might be distributed in the manner described by MARSHALL. In quite young specimens of *E. imperialis* as well as of *E. marshalli*, I find not only the dermal membrane but also the gastral and the canalar membrane respresented by quite thin trabeculæ, which are nowhere membranously developed. I regard this as the primitive condition of the trabeculæ at the surfaces and the membranous state as being acquired after a certain stage of growth.

In connection with the ectosome let me here say a word about the *endosome*. I consider this as being in its fullest development in those Hexactinellida, as, e.g., most Rossellids, in which the gastral skeleton is so highly developed as to form a continuous latticework covering the inner apertures of the excurrent canals. In such cases, the main spicules of the latticework—the autogastralia—are generally hexactins disposed in much the same way as the hexactin-dermalia of the Euplectellid ectosome; consequently, the endosomal trabeculæ connected with the autogastralia likewise exhibits an arrangement more or less similar to that in the Euplectellid ectosome. Now, in *Euplectella*, as also in certain other genera, the gastralia are far too few to form a continuous latticework; so that the inner apertures of the excurrent canals remain perfectly open. Moreover, the gastralia present are pentactins lacking the freely projecting proximal ray; and what here exists of the endosome between the excurrent apertures, is represented merely by the trabeculæ delimiting the internal trabecular layer from the gastral cavity, very much in the same way—*mutatis mutandis*—as the ectosome (dermal membrane) is represented in those species in which the freely outstanding distal ray is wanting to the dermalia. The said trabeculæ (not excluding those of *E. marshalli*), though often cobweb-like and indistinguishable from those more deeply situated, are at places spread out into a more or less extensive film-like membrane, a circumstance which makes the name *gastral membrane* appear all the more applicable to them inasmuch as they make up the lining of the gastral surface. The gastral membrane is continued into the excurrent canals as the *canalar membrane*.

The intertrabecular lacunæ underlying the gastral and the

canalar membrane (subgastral and subcanalar lacunæ) are never specially widened as the subdermal lacunæ or cavities are. Hence, the layer occupied by them (i.e., the internal trabecular layer) is much thinner and contains a much less quantity of the trabeculæ than does the peripheral trabecular layer outside the choanosome.

Having dealt with the ectosome and the endosome in their relation to the skeletal parts supporting them, it may not be amiss here to complete our account of the relation existing between the soft parts and the spicules in the choanosome. Leaving the hexasters out of question, the spicules and spicular parts that enter into the composition of the choanosome are: 1) the entire parenchymalia, 2) the proximal rays of the dermalia and 3) the distal rays of the gastralia. All these are distributed on either side of, and nearly completely separated into an outer and an inner set by, the chamber-layer. At the oscular edge the chamber-layer ceases to exist and the two sets of course mix together. In other situations I hold it exceedingly doubtful if there exist any spicules which penetrate right through the chamber-layer. The point is rather difficult to settle by the examination of sections and still more so by any other method, but I have never once noticed, not only in *Euplectella* but also in any other Hexactinellid that I have studied, a spicular ray which undoubtedly passed through the chamber-layer. Certain it is that the wall itself of the flagellated chambers is never pierced through by spicules; so that if ever a spicule does extend across the layer, it must do so between the separate chambers. I should think that the chamber-layer, in extending itself and making evaginations with the growth of the sponge, pushes its way in the intervals between the spicules present and that

subsequently the growth of the spicules on either side of the layer takes place *within* the limits of their respective trabecular systems.

The outer set of the choanosomal spicules exhibits a much greater development than the inner in the number of individual spicules, some of which here attain their largest size and also frequently group themselves into compact fascicles. This peculiarity is evidently correlated with the relatively large and continuous extent of, and the abundance of trabeculæ in, the space occupied by the set in question. Included in the set are all the numerous and long proximal rays of the dermalia and the greater part of the entire parenchymalia. Amongst the latter belong here the most important parts of the skeleton, viz., all the beams of the skeletal framework. These lie apparently in the deepest fundus of the recesses belonging to the external trabecular layer and consequently close to the gastral surface of the sponge-wall. We may consider the chamber-layer as properly lying closely *inside* the framework and as forming protuberances wherever the meshes and other interstices of the latter permit. Exactly the same relation plainly obtains between the dictyonal framework and the chamber-layer in the Dictyonina. In *Euplectella* it is not always easy to clearly make out the relation on sections, owing to the confusing intermixture of spicules and chambers ; however, the appearance of the numerous small and shallow excurrent canals occurring all over the gastral surface of the skeletal beams sufficiently attests the presence of the chamber-layer *inside* the beams. Of the rest of the parenchymalia belonging to the outer set, a small portion runs in a thin loose layer on the external choanosomal surface over the blind ends of the chamber-layer evaginations, while a by far larger portion traverses in all directions the interspace

between the said evaginations in association with the straight penetrating proximal rays of the dermalia. The said spicules and their bundles stand of course in connection with the trabecular system of the region and leave open the external apertures as well as the lumen of the incurrent canals, to which they partially furnish an incomplete wall.

On the other hand, the inner set of the choanosomal spicules is comparatively very weakly developed, a fact corresponding to the sparseness of the trabeculæ and the thinness of their layer on that side. In the first place, the distal rays of the gastralia and of the canalaria are neither so numerous nor so long as the proximal rays of the dermalia on the outside. Further, the parenchymalia of the inner set, which in part go to supplement the gastralia and the canalaria in supporting the respective lining membranes, are decidedly not numerous; they are moreover all thin and if grouped at all, appear at the most in thin loose strands.

All the soft parts alluded to in the above account are found in the cuff, in the sieve-plate beams and in the bottom-plate in essentially the same arrangement as in the lateral wall. I emphasize this fact, because it clearly manifests the identical nature of the body-parts just mentioned and furthermore serves to give basis for regarding all the large gaps in the lateral wall, in the sieve-plate and in the bottom-plate alike as oscula (see pp. 38, 39, 94).

To follow, by way of a *résumé*, the course of water in its passage through the sponge-wall: Through the pores of the dermal membrane and the intertrabecular lacunæ of the ectosome, it enters into the subdermal cavity. Here it almost directly bathes

the external surface of the most peripherally situated flagellated chambers; a large portion of it, however, passes, in order to reach the more deeply situated chambers, into the intertrabecular lacunæ between the chamber-layer evaginations, at places directly and at other places by means of the excurrent canals. As will be shown in the next chapter, the water enters into each flagellated chamber through innumerable minute prosopyles to find exit by a single large apopyle into the intertrabecular lacunæ inside the chamber-layer. It then finds its way out into the gastral cavity either directly through the gastral membrane or by way of the excurrent canals after passing through the canalar membrane, according as the chambers are situated in the deepest part of the choanosome or in more peripheral positions. Final discharge takes places through the oscula in the sieve-plate, in the lateral wall and in the bottom-plate,—probably most energetically through those of the first named structure (sieve-plate meshes).

I will now proceed to give the results of my observations on the structural details and relations of the flagellated chambers, of the trabeculæ, &c., beginning with the

Flagellated chamber.—In shape the individual chambers are generally cup-like, thimble-like or glove-finger-like (see Pl. IV, fig. 28).* They mostly measure 80-200 μ in length,

*This, as is well known, is the most usual form of the Hexactinellidan chamber. Quite a different development may however be attained by the chambers of certain Hyalonematid species, though in all probability as the result of the secondary branching and anastomosing of the original saccular form. For instance, in *Hyalonema affine* Marsh. and *Sericolophus reflexus* (Ij.) (= *Hyalonema reflexum* Ij.) I have determined after a careful study that the chambers are represented by an intercommunicating system of canals, whose wall consists of the membrana reticularis. The general arrangement of the flagellated canals strongly reminds one of the configuration of a *Farrea* colony.

occasionally being as long as 275 μ. Those situated in the periphery of the choanosome and adjoining the subdermal cavity are, on the whole, somewhat longer than others in deeper positions. The cross-section is approximately circular, with a diameter of 45-90 μ (about 75 μ on an average).

The cavity within the delicate chamber-wall is always empty,—I mean, perfectly free of trabeculæ. The broadly open, truncated end is the so-called apopyle, by which the chambers open into the lacunæ of the internal trabecular layer. On nearly the entire external surface they expose themselves directly to the incurrent lacunæ of the external trabecular layer. Here and there on that surface the fine branched ends of the external trabeculæ find their insertion (Pl. V, fig. 36).

Sometimes the chamber shows one or more outbulgings on the sides or near the outer end, and these may sometimes be so prominently developed as to bring about the appearance of a lobed chamber. In such cases the wall (reticular membrane) passes without doubt continuously from one lobe into another, making a sharp or a rounded bending. I think these outbulgings or diverticula indicate the process by which the chambers multiply themselves. After reaching a certain stage of development, the daughter-chambers should become histologically discontinuous and acquire a certain degree of independence, though remaining side by side and connected together in the manner soon to be described.

In forming the chamber-layer often alluded to, the fully formed chambers are arranged close together with the apopyles all directed the same way, without however mutually pressing one another at any point. Hence, the chambers as well as the apopyles remain round or roundish in circumference, leaving an

interspace between and around them except in places along the convex sides of any two adjoining chambers, where, as it not infrequently happens, the outer surfaces of these may lie to a greater or less extent in direct contact with each other. The point in question may best be studied on either real or optical sections across the chambers. The said interspace, which scarcely needs be pointed out as a part of the incurrent lacunar system of the external trabecular layer, is broadest where three or sometimes more chambers at a time give boundary to it (Pl. V, fig. 43). The corners of such a space extend into the exceedingly narrow cleft between every two chambers, which cleft, as above mentioned, may at times be obliterated by the coming in contact of the opposite surfaces. Even in the latter case, I think, the contact surfaces, so far as the parts of the wall concerned show the characteristic reticular structure, are not in actual fusion, though sometimes a fusion may occur at points where the chambers come in contact at the rim (marginal membrane), in which part the chamber-wall is, as will soon be seen, structurally the same as the trabeculæ.

The intercameral space above referred to is traversed by fine branching trabeculæ (fig. 43, *tr.*), which extend between chamber-walls or connect these with the supporting spicules and serve to keep the chambers expanded and in position. Close to the chamber-rim the trabeculæ are replaced by an exceedingly thin, fairly continuous membrane—the *connecting membrane* or *membrana reuniens* of F. E. Schulze (Pl. IV, fig. 22, *c.m.*)—which thus spans the interspace left between the circular apopyles and joins these together. The connecting membrane may be said to shut off the intercameral incurrent space from the excurrent lacunæ of the internal trabecular layer. Occasionally there exist

open gaps in it; however, since its situation is such that the current of water caused by the flagella in the chambers could scarcely exercise an unequal pressure on it in either direction, there should be practically a standstill of water at the gaps under normal circumstances. On both of its surfaces the membrane furnishes points of insertion for several trabeculæ. As to its morphological nature, I believe in its identity with the trabeculæ. It seems to consist of trabeculæ simply spread out in a film-like manner, just like certain parts of the dermal, the gastral or the canalar membrane. The thin protoplasm looks exactly like that of any local trabecular expansion; the nuclei, met with at long and irregular intervals, are just the same in size, appearance and staining capability as those of the trabeculæ. Moreover, where several gaps lie close together (as on the left-hand side of fig. 22), the thin beams left between them are in no way distinguishable from the ordinary trabeculæ.

Turning our attention to the chamber-wall itself, this consists *par excellence* of the reticular membrane formed by the choanocytes and of a narrow and filmy rim around the apopyle, which rim I will call the *marginal membrane*. Let the latter be first treated of here.

The *marginal membrane* (Pl. IV, fig. 22 & Pl. V, fig. 39; *m.m.*) is but another structure which is to be considered as identical in nature with the trabeculæ. It is in no distinguishable feature different from the connecting membrane. Like this it is occasionally fenestrated and where the gaps occur close together, the appearance is exactly like that of a trabecular cobweb. The protoplasm is seen at places to be directly continuous with the trabeculæ arising from or inserted in it (figs. 22 & 39). The

nuclei (fig. 39, *tr.n.*) are indistinguishable from the trabecular nuclei, but quite distinct from the choanocyte nuclei with which they may lie side by side. The edge of the membrane around the apopyle may be said to be even and free, except for the isolated trabeculæ which may sometimes proceed directly from it. At a short distance from the free edge, the marginal membrane passes into the reticular membrane and at the same time into the connecting membrane as well. With the latter it is uninterruptedly continuous. Into the former it merges rapidly but without any definable demarcation, as will best be judged from fig. 39. I might as well have described the connecting and the marginal membrane as one and the same part with which the reticular membrane comes into juncture.

Of quite usual occurrence is the fact that the chambers are somewhat contracted at the marginal membrane; so that, when looked at from either the outside or inside of the apopyle at that end, this appears surrounded by a narrow ring of the marginal membrane in a manner that reminds one of the velum in Craspedote Medusæ (fig. 22, *m.m.*). As seen in optical sections passing lengthwise through consecutive chambers, the opposite side-walls of two adjoining chambers run down close together, or perhaps in direct apposition, toward the rims, finally to diverge more or less from each other when they come to the marginal membrane. Shortly before they freely end, the connecting membrane, likewise in optical section, stretches across between them. However, it must not be thought that such a state is invariably found. Sometimes the chamber-wall runs straight out when they come to the marginal membrane, which may then, in certain parts of its circumference, lie in contact and probably in fusion with the marginal membrane of the neighboring chamber.

A relation similar to that between the reticular and the marginal membrane in the chamber-wall seems to be repeated in the transition of the chamber-layer into the general trabecular system. Such a transition should occur around every osculum, where the chamber-layer must have termination. In *Euplectella* I have not been able to bring this termination into view, probably in consequence of the complicated folding of the layer close to the oscular edge. Whereas, in certain Hyalonematids and Rossellids it was not difficult to determine on both sections and surface-views that, close to the thin oscular edge, the chamber-layer was represented by an irregularly undulating, continuous sheet of the reticular membrane, whose reticulation finally became merged into, and indistinguishable from, that of the trabecular system.

The *reticular membrane*, or as it has been called by F. E. SCHULZE the *membrana reticularis* (Pl. V, figs. 36-43), forms one of the most characteristic features in the organisation of the Hexactinellida. It consists of peculiar choanocytes whose flattened and ramified bodies, in my opinion, join with one another to constitute an extremely thin and delicate layer of minutely meshed network. When seen under a microscope of moderately high power, the reticulation presents an elegant and tolerably regularly checkered pattern. Under a very high power, the pattern loses in appearance much of its regularity. The meshes, though mostly quadrate, are frequently trapezoidal, rhomboid or triangular in shape, with usually rounded corners. The sides measure 3-7 μ in length.

From all that I have seen of the reticular membrane not only in *Euplectella* but also in a series of Hyalonematid, Rossellid

and Dictyonine species,* I can not but maintain that the meshes in question are all open and admit of a free passage of water from the incurrent lacunæ into the interior of the chamber. Only when the specimen is badly preserved or when the protoplasm of the choanocytes is insufficiently stained, is difficulty experienced in deciding whether or not the mesh spaces are overspread and closed by a transparent membrane, but in successful preparations the contour line of the reticular beams stands out sharp and distinct against the perfectly empty meshes, so that there can be no doubt whatever of the freely open nature of each and every mesh in the reticular membrane. That this is not due to the drastic effect of the preserving reagents, I have fully satisfied myself by repeatedly comparing the results of experiments conducted according to different methods (see p. 34).

I regard all the numerous meshes of the reticular membrane as representing so many prosopyles. There exists among them none that is particularly distinguished from the rest by a specially large size or by a rounded shape. The above stands in marked contrast to the condition we usually observe in other sponges. As is well known, the prosopyles in certain forms occur in tolerably large numbers to each chamber, but these always break through the choanocyte epithelium in a scattered distribution. Whereas, in the Hexactinellida they are to be considered as establishing themselves in all available interstices between the individual choanocytes, converting the epithelium into a veritable sieve-membrane. This state, in my opinion, arises, because of the minimum development or, more probably, of the utter non-development, of mesoglœa in the parenchyme

*The reticular membrane of many of these species will be figured and remarked upon in future numbers of this series of Contributions.

('mesoderm'), which fact causes the excessive thinness of the trabeculæ and the direct exposure of nearly the entire external surface of the chambers to the proportionally widened incurrent lacunæ. I will return to this point again when I come to speak of the trabeculæ. Here let it be remarked that the polyprosopylar chambers of certain non-Hexactinellids seem to prepare the way for the condition seen in the Hexactinellida, and that an opposite departure in the structural respect under consideration is found in those sponges which have diplodal chambers and which are usually remarkably compact and fleshy on account of the voluminous development of the parenchyme.

The beams of the reticular membrane are generally flat and narrow bands of variable width. Here and there, they are very thin and thread-like (see figs. 37, 38). The nodal thickenings are formed by the convergence and juncture of the beams, generally four, but sometimes three or five, in number at each node. They usually contain each a single nucleus (rarely two nuclei lying side by side) and therefore represent the central portion of the choanocyte body, of which the reticular beams are but lateral processes. Sometimes in its course the process is seen to give off a branch or branches, which go to unite either with an adjacent beam or a node. When the membrane is looked at *en face*, the nucleus appears circular and is surrounded by a protoplasmic area, which is drawn out into the lateral processes. In profile view or optical section, the nucleus presents an elongate elliptical shape, indicating its marked compression on the plane of the reticular membrane. (See figs. 40, 41, 43). The node itself being likewise compressed, there is scarcely visible a protoplasmic layer on either surface of the nucleus, though at the poles of its elongated axis there exists a small protoplasmic accumulation

which is directly continuous with the thin lateral processes. I have noticed no appreciable difference in the convexity of the two sides of the nucleus, nor have I detected the presence at its distal surface of a strongly colored cap-like body, such as was seen by F. E. SCHULZE in *Schaudinnia arctica*.

The protoplasm of the nodes and beams, as it appears in hardened preparations colored with carmine or hæmatoxylin, both of which usually stain it but very faintly, consists of a clear matrix containing granules that are neither uniform in size nor in distribution. The limit of the matrix against the meshes is often scarcely perceptible, on account of its perfect clearness; in fact, the protoplasm presents itself to the eye almost by its granules alone. These are, as have also been noted by F. E. SCHULZE, frequently arranged in strings, an arrangement which seems to me to be simply due to their situation one behind another in narrow tracts of the matrix. In some preparations and sometimes in certain parts of a single preparation, I have found in greater or less abundance unusually coarse and refringent granules (fig. 38), which elsewhere are either quite absent or only solitarily present. They remain unstained by borax-carmine but readily take up acid-fuchsin. Their presence or absence presumably depends upon certain metabolic conditions of the choanocytes; they are possibly somewhat allied to, if not identical with, the inclosures of the thesocytes to be described further on.

Stained with acid-fuchsin, the protoplasm becomes tolerably well colored. It then appears at places nearly homogeneous or uniformly finely granular, and in other places with the coarser well-stained granules in addition (figs. 37, 38). As before mentioned, its external limit against the meshes stands out well

defined, without however showing the slightest indication of the presence anywhere of a limiting membrane. F. E. SCHULZE, as he described the structure of the Hexactinellidan chamber-wall for the first time, evidently believed that the choanocytes rested on a continuous basal membrane, the outer (incurrent) surface of which was furthermore assumed to be lined by a pavement-epithelium. This was a mistake. SCHULZE ('99*a*, p. 209 ; 19'*a*, p. 98) himself has been led by his recent researches into the histology of *Schaudinnia arctica* to the conviction that the membrane has no existence, and that the presence of the pavement-epithelium is questionable. I think it may be considered as a settled question that there exists no special layer of any kind outside of, and in contact with, the reticular layer of the choanocytes. SCHULZE (*l.c.*) has expressed the opinion that the fundament on which the latter layer lies, should be considered to be a relatively wide-meshed network of certain trabeculæ. I should rather say, as I have already said above, that all the trabeculæ coming to the reticular membrane simply find insertion in this for the ends of their fine dentritic branches. Some of these terminal branches are indeed seen to creep along the outer surface of the reticular membrane shortly before they terminate ; but such occurrences in the species studied by me are decidedly too few and far between to be regarded as giving a 'Grundlage' to the choanocyte layer.

The *nucleus*, whose shape and position have already been described, is plainly visible under a high magnifying power. It measures only 1.5–1.7 μ in diameter as seen in the surface view of the chamber-wall. A fine nuclear membrane seems to be present. The contents are nearly homogeneous or at most finely

and sparsely granular. As known through F. E. SCHULZE, the nucleus is remarkably poor in chromatin, on which account, it, unlike all the nuclei of other tissues, does not surpass the surrounding protoplasm in staining capacity. Nor does it contain a body which might be called the nucleolus. Hence, in certain Hexactinellid species or in a certain state of preservation, the nuclei of the choanocytes can be demonstrated only with difficulty. In the surface view of the chamber-wall stained with acid-fuchsin (fig. 37), a clear ring is observable around the nucleus at a certain focus of the microscope; this is apparently due to the refrangibility of the nuclear substance. Also a highly refractive spot is visible in a central position in each nucleus; this is due to the origin of the flagellum, which arises directly from the inner (distal) surface of the nucleus, and should not be mistaken for a nucleolus.

To F. E. SCHULZE belongs the credit of having first demonstrated the Hexactinellidan *flagellum* and *collar* in *Schaudinnia arctica*. The former structure had been long known to me from *Euplectella marshalli* and *Acanthascus cactus*, in both of which it is fairly constantly preserved in preparations fixed with corrosive sublimate. As the total length of the flagellum I may put down 17–19 μ. In the profile view it appears as a fine line, very faintly stained by acid-fuchsin (figs. 40–42). In the surface view of the chamber-wall (fig. 37), it appears in optical section as a glittering dot, which, by varying the focus of the microscope, may be made to move continuously away from, or toward, the central refractive spot of each nucleus, as the case may be.

As to the *collar*, my opinion was very uncertain for a long

time after the flagella had become known to me, although subsequent experience has proved that I had really that structure under my observation. F. E. SCHULZE's paper 'Zur Histologie der Hexactinelliden' ('99*a*) gave me fresh encouragement to renew my investigations into the matter, and for this purpose I went once again to Dōketsba in the spring of last year, in order to obtain a new supply of *E. marshalli* preserved in a number of ways. As before, corrosive sublimate as the fixing reagent gave the best results; and a careful search on sections stained with acid-fuchsin, using a very high power (Zeiss' homogene Immersion), resulted in convincing me of the indubitable presence of a collar to each cell. Having once become acquainted with its appearance, I found that it was visible in nearly equal clearness in many of my old preparations colored with borax-carmine. In order to see them well, the collars must be seen in the profile. The section should be neither too thick nor too thin; in the latter case it is difficult to recognize the chamber-wall itself. Moreover, the section of the wall must be so favorably situated that the collars and the flagella stand out in a perfectly clear light, which should not be tinted by the colored light diffused from neighboring parts lying out of the focus. I have never succeeded in perceiving the collars in optical section on the surface-view of the chamber-wall, the diffuse colored light coming from the reticular beams and nodes being sufficient to conceal them.

The collar (figs. 40–42) in the profile view appears as a narrow sheath around the base of each flagellum. It is exceedingly delicate, quite clear and very faintly colored by acid-fuchsin. The lateral contour-line is fine or moderately sharp; the distal edge-line, always very fine. The shape is variable, apparently

owing to shrinkage caused by the action of the reagents. I think it is approximately cylindrical in the natural state. In the preparations that shape is sometimes retained ; but more frequently the collar either gradually narrows toward the distal end or is somewhat narrowed in the middle section, in which latter case the distal end is often expanded in a funnel-like manner. The flagellum traverses the collar either at its middle throughout or along one of its lateral edges after having inclined to that side at a certain distance away from the origin of the flagellum in the center of the distal nuclear surface. In height the collar measures 5–6 μ (5.6 μ on an average). The breadth usually measures only $1^1/_2$–2 μ (1.7 μ on an average), i.e., about as much as the diameter of the nucleus. It may however occasionally reach 3 μ at the base or at the expanded distal end of the collar.

In one or two instances I have seen a line apparently stretching itself between and connecting the flaring rims of a few consecutive collars, which line reminded me at once of Sollas' membrane. But I have satisfied myself that it is to be regarded as something accidentally produced,—possibly a flagellum or portions of flagella laid down upon the free ends of the collars. The collars stand out freely and solitarily, being separated from one another by a comparatively wide space whose width may be said to be on the whole about equal to the distance between the nuclei of the respective choanocytes.

Observations of the chamber-wall in the *fresh state*, 2–5 hours after the capture of the specimens, did not reveal anything of much importance. The preparation of a piece of the fresh choanosome for examination under the microscope necessarily involves more or less dislocation of spicules from their proper

positions, while the trabeculæ suspending the chamber-wall suffer at places unnatural slackening and at other places tightening, or are even wholly broken off. The consequence is that the chambers mostly lose their original inflated form and may even become shriveled up, which is probably to be explained by the inherent contractility of the choanocytal protoplasm. The chamber-wall then does not show the reticular structure; I suppose the meshes have been obliterated as a result of the contraction. At the best it presents itself as a continuous layer of densely but irregularly granular protoplasm. In optical section it appears somewhat thicker than when seen in hardened preparations. Under favorable circumstances, the flagellation can be distinctly observed, though no longer in motion. The flagella seem to be somewhat more densely situated than in hardened preparations, which apparently stands in relation with the contracted state of the chamber-wall. I have also seen a number of flagella apparently emanating from little masses of granules in teased preparations.

The collar in the fresh state I have not succeeded in detecting. This failure was undoubtedly due to the fact that at the time of my investigations on fresh specimens, years ago at the Misaki Marine Laboratory, I had no knowledge of the Hexactinellidan collar and moreover no higher power at my disposal than Zeiss' objective DD, which, as I afterwards learned, is by far too weak for the clear observation of the structure in question. It may here be mentioned that in a sketch which I made, in 1895, of the chamber-wall of *Acanthascus cactus* as examined in optical section in the fresh state, I find the flagellation represented by a series of lines of unequal lengths, the shorter of which are confined to the base in junction with the layer of granular protoplasm. It occurs to me as quite possible that I have seen,

in addition to the flagella proper, the lateral contour-lines of the collars and that the shorter lines in the sketch stand for these. I regret that I have had no opportunity to renew my observations on fresh specimens.

I have of course not neglected to try silver-nitrate methods on fresh specimens with the view of demonstrating cell-outlines in the chamber-wall. The methods referred to browned the protoplasm but always failed to bring out the expected boundary lines. Not only this negative result, but also the perfectly continuous appearance of the substance constituting the reticular beams, strongly inclines me to believe that the *membrana reticularis* represents, so to say, a fenestrated syncytial layer,—in other words, that the individual choanocytes stand in organic fusion with their fellows by the aforesaid beams or the lateral protoplasmic processes. And I think this is not a phenomenon that stands quite alone in the group of the Spongida taken as a whole. For, it will be conceded by all that the reticular beams of the Hexactinellidan chamber-wall correspond in all probability to those protoplasmic processes which are known to extend radially from the bases of choanocytes in a number of other sponges. For several species of the Calcarea (*Ascetta primordialis*, *Sycandra raphanus*, *Vosmaeria corticata*), R. v. LENDENFELD ('92) has stated that these processes anastomose and form a network. SOLLAS ('88, p. XXXVIII) has also made the statement, I suppose for the Spongida generally, that the same continuously unite each choanocyte with its surrounding fellows.

The structure of the chamber-wall and of the single choanocytes as described by me in the above unfortunately does not accord in some important points with the description given by

F. E. SCHULZE ('99*a*, 19'*a*) of the same in *Schaudinnia arctica*.

Firstly, as to the open or closed nature of the generality of the meshes in the reticular membrane. According to SCHULZE they should be closed in *Schaudinnia arctica*, as he originally believed them to be likewise in *Eupl. aspergillum* and in several other species ('80, '87), though not in the same way. His original conception seems to have been that the choanocytes lay apart from one another but were joined together by band-like connecting bridges and were disposed in a layer over and upon a continuous basal membrane, much in the same manner as is observed in other classes of the Spongida. His histological study of *Schaudinnia arctica*, however, led him to the belief that such a basal membrane, or in fact any membrane which might delimit the chamber-wall from the incurrent lacunæ did not exist (see p. 137); and he thus may be said to have come very near to recognizing what I consider to be the fact, viz., the open state of all the meshes of the reticular membrane.

SCHULZE however entertained quite a different view of the matter ('99*a*, p. 201; 19'*a*, p. 98). The choanocyte is described by him as having a thin basal expansion—a 'fussplattenartige Ausbreitung des Basaltheiles der Zelle'—which should join with the same of the neighboring choanocytes and form a *continuous* membrane, called the 'Basalplatte.' This should be traversed by the branching and anastomosing granular bands which radiate from around the nuclei and bring about the reticular pattern visible when looked at on the surface. I make bold to say that the existence of such a 'Basalplatte' is to me exceedingly doubtful, but it would be well to leave this moot point to be decided by the results of further investigations.

Secondly, as to the prosopyles. SCHULZE ('80, '87, '99*a*,

19'*a*) has always represented these to be smooth-edged roundish pores of different sizes, opening through the membranous chamber-wall in variable numbers and in irregular distribution. I should think this amounts to about the same as to say that only a limited number of the numerous meshes of the reticular membrane are open, which in my view should be the case with all.

I beg to remark that when insufficiently stained, or when subjected to macerating influences, the choanocytal protoplasm appears quite ill-defined as to its limiting contour; and then, especially if there should be found in the quadrate meshes some granules or strings of granules,—which in reality belong either to the finer branch-beams or to the terminal branches of certain trabeculæ, and which in other cases seem to be due to disintegration of the protoplasm,—one may easily be led to think that the meshes are overspread with a transparent film, while here and there may occur such as happen to be exceptionally clean within, but, which being surrounded by a granular tract, may be taken for the only ones that are open.

Thirdly, as regards the general shape of the choanocyte. According to SCHULZE, it should be nearly cylindrical in the living state and somewhat wine-glass-like when preserved. Distally to the thin basal expansion already referred to, there should follow an elongated neck-like section of the cell-body, which section reminds us of the collum or rostrum of the choanocytes in other sponges. The parts in question in consecutive choanocytes were observed to be separated by a system of narrow interspaces. Distally they broadened, becoming somewhat trumpet-like, and were finally capped each with a broad collar. A delicate central axial-thread extended from the center of the distal

surface of the basally situated nucleus to the origin of the flagellum at the terminal surface of the collum-like section.

Now the choanocyte of *E. marshalli*, as I have described it, lacks the collum-like middle section. It has been described as consisting only of a collar and of a flattened body, which at any rate partially corresponds with the base of the choanocytes in SCHULZE's sense (I say *partially*, merely because I do not assume the presence of a web-like closing membrane between the lateral processes or reticular beams).

In attempting to reconcile the above difference in our standpoints, the following possibilities suggest themselves: 1) *The collum-like section may be something that really is entirely wanting in E. marshalli.* In view of the general uniformity of histological structure throughout the entire group, the assumption of such a marked variation seems to be scarcely warranted. And yet, a considerable range of variation, so far as the size of the choanocytes is concerned, is to be admitted; for, SCHULZE has given for the total height of choanocytes in *S. arctica* 10-12 μ, and for the greatest breadth 5.6 μ; against which dimensions, the size of the same in *E. marshalli* as found by me is only about one-half as large or even smaller. 2) *The part which I have taken solely for the collar may include the collum-like section of the cell-body.* The narrow shape of that part seems to lend color to this possibility. However, I have never detected the slightest difference in the appearance of the basal and distal parts of the structure in question. It is uniformly and homogeneously transparent throughout. 3) *I may have seen only the collum-like section, but not the true collar.* I must declare myself against this, as well as against the preceding, assumption, on the ground that the flagellum is frequently seen to bend in one way or the other

soon after its origin from the nuclear surface, and to pursue its course edgewise, either for a part or the whole of the remainder of its passage through the structure in question. This fact indicates that the latter structure must be hollow from its base. 4) *The collum-like section may be only a portion of the collar.* Significant in this respect appear the flattened cake-like form of the basally situated nucleus, notwithstanding the elongate shape assigned to the cell-body. It is also to be noted that the collum-like section should have, according to the describer, *clear* contents, the granules being apparently confined to the region immediately around the nucleus and to the reticular bands in the membranous basal expansion,—a fact which strikes me as somewhat remarkable. And, I venture to say that some of SCHULZE's figures—notably 19'*a*, Taf. III, Fig. 4, which shows no material difference in appearance between the collar and the collum, while the angular lateral edge-line between the two parts may be taken as due simply to the presence of the peculiar connecting membrane at that level—are in no small measure suited to give an impression pointing to the possibility, not to say the probability, of the present assumption. However, it will require more substantial grounds to establish the point. After all, I am inclined to give weight only to the first and the last of the four above-mentioned possibilities in the way of explaining the position I have taken as regards the structure of the choanocyte in *E. marshalli.*

Fourthly, an interesting discovery was made by SCHULZE in *S. arctica* in that the closely standing distal ends of the collum-like section of the choanocytes, at the boundary between them and the collar, were connected laterally with one another by a cementing mass, though at times they appeared there to be simply sticking together. In the plate-like connecting mass sur-

rounded by three or four adjacent cells, there were sometimes found roundish pores, which should allow the entrance of water into the chamber. In *E. marshalli* I have seen no trace whatever of this kind of connection between the cells. It is probably a sort of an accessory arrangement which is not of universal occurrence among the Hexactinellida.

The trabeculæ.—These are in general fine and thread-like, in places band-like. The disposition of their branching and anastomosing strongly reminds one of the irregular web woven by certain spiders (*tr.*, Pl. IV, fig. 22; Pl. V, figs. 36, 43; see also Pl. VIII, figs. 29, 30). The meshes are of quite indefinite shape and size. Generally speaking, the trabeculæ stand for the mesenchyme of other sponges, but never and nowhere do they form a bulky mass or a compact layer of any considerable thickness*, though in places they may be expanded into film-like membranes. Such expansions occur here and there in the deeper parts, at points where three or more trabeculæ join together, and are in appearance somewhat alike the nodal confluence of the filamentous pseudopodia of certain Rhizopods.

The same membranous development of the trabeculæ, but on a far greater scale, is seen in certain definite positions, especially on the surfaces delimiting the sponge from the exterior. Here belong the dermal†, the gastral and the canalar membranes, as

* The diagrammatic figure, recently given by Delage and Hérouard in the 'Zoologie Concrète' (T. II, Pl. 8, fig. 4), representing the relation of parts in the wall of *Euplectella*, is fitted to give an altogether erroneous idea of the structure, in that the choanosome is shown as a thick folded layer of compact 'mésoderme' inclosing the chambers, while both the ectosome and the endosome are given likewise as thick, minutely perforated layers connected with the choanosome by solid pillars. Their other diagrams on Pl. II, relating to the Hexactinellida, are much better. But these, as also the matters embodied in the text, do not call for special comment, being entirely based on the representations of F. E. Schulze.

† For the fact that this layer in *E. marshalli* hardly deserves to be called a membrane, on account of the general thread-like development of its beams, see *ante*, p. 123.

well as the oscular membrane, the marginal membrane and the membrana reuniens, all of which have been spoken of before as adaptations of the general trabecular system. I will repeat that all these membranes are not different from the thread-like trabeculæ either in histological character or in the manner of their occurrence. I am even under the impression that, during life, there obtains in the tissue concerned a certain degree of instability in the form, whether membranous or filamentous, which is assumed at different times. As the result of a certain stimulus, causing protoplasmic contraction, a membranous area may thin out and finally break apart in the middle; then, by enlargement of the gap or gaps thus produced, the area may readily convert itself into a mesh or a series of meshes bounded by filamentous beams (see Pl. VIII, fig. 30). Contrariwise, the trabecular cobweb may become so close meshed as to finally fuse together into a continuous sheet, or a part of it may be so drawn out as to form a filmy expansion. Indications of such transformations are indeed very frequently to be observed. This theory presupposes a viscous semi-fluid nature of the trabecular substance, which assumption seems also to explain the apparent facility with which floricomes traverse a dense cobweb of trabeculæ in order to reach the tips of the dermal hilt-rays. The above nature appears to me all the more assumable, since, as will soon be dwelt upon at length, I am inclined to ascribe no pinacocytal covering to the entire trabecular system, but to regard this as a network of bare-surfaced syncytial protoplasm.

A spicular sheath, consisting of a continuous layer of the soft tissue, has been assumed or mentioned by some writers (Thomson '70, p. 710; Schulze '87, p. 24). Although I have never been able to prove the fact, yet I can not but hold it very

likely that the spicules, during their growth or the deposition of new siliceous matter over their surface, are covered uniformly all over by an excessively thin layer of the matrix. On the other hand, the impression I have repeatedly received from the observation of the larger parenchymalia in well-colored preparations, has been that these have no other coating than a layer of an irregularly meshed trabecular network, lying in direct contact with the spicular surface. It is not at all improbable that many old spicules, though *in situ* within the bounds of the sponge-wall, are to be considered as lying partially outside of the soft parts, as the prostals as well as the rhaphides and the floricomes at the tips of the dermal hilt-rays undoubtedly do.

In the fresh state (2–5 hours after capture), I have observed the trabecular substance to be either simply minutely and densely granular or composed of a clear homogeneous ground-substance inclosing a greater or less quantity of opaque and irregular granules. The nuclei presented themselves as refractive spherules. Nowhere on the surface was flagellation observed. Nor have I been able, notwithstanding my special endeavors with silver-nitrate and methylenblau methods, to bring out cell-outlines either on or in the trabeculæ. When carmine particles were added to the fresh preparation, they stuck to the trabecular surface with a certain degree of firmness, so that they could not be moved by the water current produced under the cover-glass by the use of a blotting-paper. Watching such preparations attentively or viewing them at brief intervals under the microscope, the while keeping them perfectly quiet, the attached carmine particles, and no less the nuclei and the protoplasmic granules, were seen for some time slowly to change their relative positions, which change was accompanied by a slight alteration in the form

of the trabecula itself. This indication of life, which I have observed in *E. marshalli* as well as in *Acanthascus cactus*, I interpret as due to protoplasmic contractility. As for a flow of protoplasm, it is not possible, since the trabeculæ, though soft, pliant and easily destroyed by pressure, are much too consistent to be with any exactness called fluid.

Observed in hardened preparations, the substance of the filamentous trabeculæ is tolerably well stained and dense-looking, being either nearly homogeneous or granulated in varying degrees. The membranous expansions, looked at face on, usually present a somewhat less dense or clearer appearance, apparently due to the thinning out of their substance in forming such areas. Here are seen granules and irregular particles or little streaks, which are scattered either somewhat uniformly or in a manner suggestive of a reticular arrangement (Pl. IV, fig. 23; Pl. VIII, fig. 30). This appearance may be partially the result of the hardening process. A fibrous or streaked appearance is also not infrequently noticeable, generally running parallel with the free edges of the band-like or otherwise membranously developed trabeculæ. In most such cases, I have convinced myself of the fact that the appearance is due, not to the real existence of differentiated fibers, but to fine wrinkles which are probably produced by contraction; for, the streaks are not only of very indefinite contour in certain places, but also at the ends are seen gradually to lose themselves in the membrane as it generally appears. The edge-line of the trabeculæ is always of simple contour.

Sometimes unusually coarse, refringent and well-stained granules are found in isolated occurrence. These are probably the same as those found inclosed in the thesocytes to be described further on.

The *trabecular nuclei* (Pl. IV, fig. 23; Pl. V, figs. 36, 43, &c.; fig. 39, *tr. n.*)—by which name I designate the nuclei belonging to the protoplasmic substance of the trabeculæ—are small and spherical, measuring 2 μ and less in diameter (say, $1^3/_4$ μ on an average). Unlike the choanocyte nuclei, they stain very deeply and usually contain a single, sometimes a few, chromatic bodies which look dark or strongly refringent at different foci of the microscope. The nuclei are quite common and are scattered in rather irregular distribution. While sometimes two or more lie not far distant from one another and at tolerably uniform intervals, in other places a trabecula, especially when of filamentous form, may stretch itself for a relatively considerable length without showing one. The nuclei have their seat by no means confined to, nor invariably at, the expanded parts or the branching points, but may occur at any point in the course of trabeculæ. On account of the thinness of these, the nucleus is seen, when looked at in a certain direction, to project more or less on one side or on the other or on both; and often it even appears to be simply attached by a small portion of its circumference.

In connection with the trabeculæ are certain cells which have well-defined cell-bodies. These will be separately dealt with in the chapter to follow. The nuclei now in question—the trabecular nuclei—are all 'free,' i. e., without a cell-outline around them. The trabecular substance, in which they lie, is throughout of a uniform appearance, showing only such differences as may be accounted for by the variation of its thickness in different places. The application of double-staining and triple-staining processes has never resulted in demonstrating the presence in it of parts with any difference in the power of selecting

stains. It will then require no further words to explain that I regard the trabeculæ as consisting of the fused cytoplasm of the cells represented by the above free nuclei. Here I leave this point, to resume it soon again.

The question whether the trabeculæ have a pinacocyte covering or not, I am fully aware, is a delicate one. F. E. SCHULZE has always assumed its presence in the forms studied by him, an assumption which seems quite justifiable from a theoretical point of view. However, as before indicated, I have been led to the contrary opinion, though at first I felt much diffidence in coming to this conclusion. Mention has already been made (p. 33) of my failure to demonstrate cell-outlines on the trabecular surface. The history of our knowledge of the pavement epithelium in the Spongida teaches us caution in drawing conclusions from that negative result; but in the present case, I am quite at loss to believe that my methods were in any way at fault. Besides, there is another circumstance, which, simple as it is, seems to me to deserve due consideration. It is the excessive thinness in which the trabeculæ, whether filamentous or membranous, so often present themselves in all parts of the sponge-body (see Pl. V, fig. 43, *tr.*; also Pl. VIII, fig. 30). The thinness is such that barely enough room is given for the protoplasmic granules to arrange themselves in a single row or layer, as the case may be, and this seems to be scarcely compatible with the assumption of the plurality of differentiated tissues or layers. To all appearance, the thinner trabeculæ are nothing more than simple threads or films of the protoplasm. In the absence of indications to the contrary, I see no ground for hesitating to ascribe the same

structural conception to the relatively thicker parts of the trabeculæ.

To be plain, my notion is that for once among the sponges we find in the Hexactinellids that the development of pinacocytes, both as an investing of the exterior and a lining of all the internal cavities and passages, is entirely suppressed. This seems to be in harmony with a certain point in the structure of the chamber-wall as described by me, *viz.*, that the convex outer (incurrent) surface of this is, so to speak, naked, the basal ends of the choanocytes being directly exposed to the water,—a fact which I think is nearly, if not quite, admitted also by F. E. SCHULZE ('99*a*, p. 209; 19'*a*, p. 98), in that the existence of a basement membrane at the place is denied by him and that of a pavement epithelium held *doubtful*, while the choanocyte layer is considered as resting on a relatively *wide-meshed network of trabeculæ*.

Be that as it may, F. E. SCHULZE's representation of certain nuclei and cells as pinacocytes seems to be open to discussion. In *E. aspergillum* ('80, pp. 669–671; '87, pp. 23, 24), he distinguished the three following kinds of nuclei or cells in the trabeculæ:

1) Small, spherical nuclei, abundantly and tolerably uniformly scattered. These were seen on profile view to project a little above the general surface of the trabeculæ, and were thus considered to occupy the most superficial position and on that account to represent flat epithelial cells, whose outlines were certainly not seen. The nuclei in question evidently corresponds—in part at least—to those which I have called the trabecular nuclei. It is then important to decide if their seat in the trabeculæ is really superficial in relation to that of certain other nuclei or cells in the same. This is by no means so, to judge

of what I have seen of the same nuclei in *E. marshalli* and in a number of other Hexactinellid species, the histology of which will be duly remarked upon in the future numbers of this series of Contributions. On the contrary, the occurrence *on* the syncytial trabecular thread, of certain cells, which on account of their well-defined spherical or ovoid bodies cannot possibly be pinacocytes, is quite common. The projected state of the trabecular nuclei, as they have come under my observation, was in nearly all cases apparently due to the simple fact that the space in the protoplasm was not sufficient to completely include them. The unilateral situation of the nuclei, especially in the thinner trabecular thread, may also be considered as the result of an uninterrupted and most effective bringing about of protoplasmic continuity, which may be of primary importance to the trabeculæ considered as a connective substance.

2) Somewhat larger and more oval-shaped nuclei with little protoplasm around them, giving simple stellate or spindle-like shape to the cells. These appear to have been seen in relatively smaller numbers and are regarded as representing connective-tissue cells lying in a hyaline matrix. It occurs to me likely that the 'nuclei' here referred to, correspond in part at least to certain distinct *cells*, which I will describe in a later chapter under the designation of archæocytes. My grounds for holding that opinion will be given presently in connection with apparently the same 'nuclei' described by SCHULZE from *Schaudinnia arctica*. The nature of the protoplasmic space around the alleged nuclei, seen by SCHULZE in *E. aspergillum* but apparently not in *S. arctica*, remains incomprehensible to me, unless it be considered to be a part of the protoplasm of the trabecular

syncytium having especially concentrated granulation or being otherwise exceptionally modified.

3) Larger cells, likewise considered to be situated in the hyaline connective-tissue matrix and distinguished by a more or less abundant accumulation of refractive, intensely stained granules of various sizes. These granules were occasionally of a brownish or yellowish color. They have been compared, quite justly I think, to fat or starch in the physiological sense. I believe that this kind of cells are of very general occurrence in the Hexactinellida, and I take it to be analogous, and in all probability homologous too, to the thesocytes (SOLLAS) of non-Hexactinellids. (See anon under Thesocytes).

Let us now compare the above with the results arrived at by the same investigator in the case of *Schaudinnia arctica* ('99 *a*, pp. 206–209; 19'*a*, p. 98) and connect therewith such remarks as may seem conducive to a clear understanding of the matter. In that species, the nuclei or cells distinguished by SCHULZE in the trabeculæ are essentially the following two:

Firstly: cells containing a mass of peculiar spherules and conglomerates ('Knollen') around the nucleus, and which are numerously present on the dermal and the gastral membrane, on the thicker subdermal and subgastral trabeculæ, and around as well as between the apopylar openings of the chambers. On account of the bulky contents, they project more or less over the surface of the said parts in a hump-like manner. These cells are taken by F. E. SCHULZE for pinacocytes. However, from the nature of the 'Knollen' described ('99*a*, p. 207), it is exceedingly probable, and indeed scarcely to be doubted, that we have here to do with the thesocytes above referred to under (3),—cells, which, unless I am greately mistaken in my homologization,

SCHULZE had before in *E. aspergillum* associated with the connective substance, instead of classing them as flat epithelial cells. I am decidedly in favor of this older view of SCHULZE's. The cells in question, as known to me from *Euplectella* and a number of Hyalonematids, Rossellids, &c.,—which cells I have no doubt belong to one and the same class of cells both morphologically and physiologically,—always have plump bodies and show *clearly defined cell-boundaries, which as a rule are well separated from one another.* In most species, e.g., *E. marshalli*, they are ordinarily quite *sparingly* and *isolatedly* present, while in certain places and under special circumstances they may occur in large, compact masses (Pl. IV, fig. 24). (See anon under Thesocytes). These facts in my view militate against the propriety of attributing to the cells an epithelial nature, in spite of their most superficial situation. Even granting their epithelium-like arrangement, their homology with the true pinacocytes may be questioned, because the latter cells, so far as my knowledge of them goes, are never known to have similar contents, while certain other cells which do possess such contents—i. e., the thesocytes, which are not improbably identical cells in all sponges of different classes—are found scattered invariably in the mesenchyme of such sponges as show besides a true pinacocytal epithelium.

It is important to note that SCHULZE did not find in *Schaudinnia arctica* the alleged epithelial cells on all parts of the trabecular systems. They were evidently not present on the finer intercameral, subdermal and subgastral trabeculæ. "Es könnte daher sein, dass diese Verbindungsbalken einer besonderen epithelialen Bekleidung entbehren und ganz aus der...Bindesubstanz bestehen" ('99*a*, p. 208) is his conclusion. While maintaining the presence of an epithelium on the thicker trabeculæ,

the possibility and perhaps the probability of its absence on the thinner ones is thus admitted by him. Such a partiality, if true, must be said at least to indicate a very remarkable case for an epithelium; whereas, if we had to do with cells of mesenchymal nature, there would be nothing extraordinary in finding these attached only to such thicker beams as are capable of bearing them on.

Secondly; nuclei without the 'Knollen' around them, and which are numerously found, apparently situated in the connective-tissue substance of the trabecular threads and membranes. These nuclei are said to be on the average somewhat larger and of a more oval form than those of the cells with the 'Knollen,' though in some parts of the trabecular system there are present a number of such as are indistinguishable from the latter nuclei in point of size or of other features. In view of this agreement shown by the relatively smaller nuclei under consideration, SCHULZE ('99*a*, p. 208) leaves open the possibility, if I understand him aright, that these smaller nuclei may belong to flat epithelial cells which have not accumulated the 'Knollen' in their bodies. The relatively larger ones are at any rate regarded as the connective-tissue nuclei. No special protoplasmic space around them seems to have been seen, for no mention of it is made. These nuclei are said to be the only kind that are found in the thinner trabeculæ and especially in those spanning the spaces between the chambers; so that, to follow the writer's expression as nearly as possible, 'here at least' the existence of an epithelial covering could not be ascertained (*l.c.*, p. 209). However, he expressly leaves undecided (19'*a*, p. 98) whether or not the difference in size of the nuclei 'alone and in all cases suffices for the distinction of the two kinds of cells' (i.e., flat epithelial cells and connective-tissue cells).

On the whole, these ideas of SCHULZE concerning the nuclei do not differ from those expressed by him before with regard to the smaller and the larger nuclei in the trabeculæ of *E. aspergillum*, mentioned and remarked upon respectively by me under (1) and (2) on pp. 153–154. This might naturally follow, if, as I have assumed, the cells with granular contents in *E. aspergillum*, mentioned by SCHULZE and referred to by me under (3) on p. 155, are the same kind of cells as the 'Knollen' cells of SCHULZE (thesocytes); for, in that case, the nuclei without the 'Knollen' in *S. arctica* would have in *E. aspergillum* nothing to correspond to but the nuclei I have mentioned under (1) and (2). A new point is that the cells represented by the 'smaller nuclei' in the trabeculæ, or by at least some of these nuclei, are possibly identical with the 'Knollen' cells or (according to my interpretation) thesocytes. The implication is that one of these two kinds of cells may be directly derived from the other. This seems to me highly improbable; for, I think I have grounds to believe that the thesocytes arise, on the contrary, from the so-called 'larger nuclei' of SCHULZE.

In attempting to establish my position here taken, I will begin by stating that I can not help entertaining a doubt as to whether the size given by SCHULZE for the 'larger nuclei' found in the trabeculæ refers to real nuclei,—if a certain mistake is not here involved in spite of his wonted accuracy in observations. According to him, they should be 3–4 μ large (against ca. 2 μ of the nuclei of 'Knollen' cells; 19'*a*, p. 98). To speak from my own experience, the nuclei in the trabeculæ, irrespective of their having a well delimited cell-body or not, are all tolerably uniform in size and general appearance within the limit of the same Hexactinellid species at least, if not of the entire class. They

are always very small, fluctuating within only an inconsiderable range of variation in this respect; in shape they are constantly spherical or approximately so. In *E. marshalli* they rarely, if ever, exceed 2 μ in diameter, while the smallest measure about $1^1/_2$ μ,—a variation of say less than half a μ. This does not quite agree with SCHULZE's statements. However, this fact alone would not perhaps have led me to the above skepticism, were it not for another circumstance which serves to account for the size ascribed by SCHULZE to the 'larger nuclei.'

As I have before indicated (p. 154, under 2.), I hold that the 'larger oval nuclei' SCHULZE's in the connective substance of both *E. aspergillum* and *S. arctica* are nothing else than, or should at least include among them, the well-defined *cells* which I call the archæocytes (Pl. V, figs. 36, 39, 43; *arch.*). For the nature and characteristics of these cells, the reader is referred to the special chapter devoted to them. Here suffice it to mention that these cells are exceedingly liable to be taken for mere nuclei, and that their distribution in the trabecular system agrees on the whole with that ascribed by SCHULZE to the 'larger nuclei' in *S. arctica*. On the other hand, I find no mention of these cells as such in the descriptions given by that investigator, though they have been undoubtedly seen by him. At all events there can be no doubt whatever that the 'larger nuclei' seen by him in groups in the immediate proximity of the flagellated chambers and taken for possible genital cells ('19*a*, p. 99),* are the same as my archæocytes, which thus seem to have been only partially recognized in that they were errorneously considered as nuclei and not as complete cells. If this be so, then the discrepancy in our observations

* The same groups of cells, likewise considered as possibly concerned with reproduction, were also seen before by SCHULZE in *Furcea occa* ('87, p. 285). Here the elements in the groups are described as '*cells*,' with nuclei which stain with special readiness.

concerning the size of the nuclei in the trabeculæ will explain itself. It is also plain that, if there prevails a general uniformity of size and appearance among all the nuclei, which I hold to be the case, the assumption of the identity of this or that kind of cells with another should lose all its validity, so long as it is founded on the similarity of their nuclei alone.

Finally I will mention here, reserving the details of my observations relative to the point to another chapter, that the thesocytes seem to be one of those kinds of cells which arise directly from the archæocytes, the transformation being effected simply by gradually accumulating the 'Knollen' in the cell-body (Pl. IV, fig. 24). It may perhaps be urged that the archæocytes may be present in some species with, and in others without, the cell-outlines, and that the size of the nuclei may likewise be a variable matter; but the fact would remain the same that the thesocytes—the 'Knollen' cells of *S. arctica* included—develop out of the 'larger nuclei' of SCHULZE.

To resume my own account of the trabeculæ. I have said in effect that these consist of a fused cytoplasm or nucleated protoplasm (syncytium) in the form of threads and membranes. It will be noticed that here recur in a measure the old sarcode-theory, O. SCHMIDT's ('64), of the sponge ground-substance, and the syncytium-theory, HAECKEL's ('72), of the 'exoderm' in calcareous sponges. Whatever fate these theories may have met in the case of other sponges, in the Hexactinellids they may be said to have preserved a certain degree of applicability. As regards the general soft tissue of the Hexactinellida in particular, there were among the older investigators some who termed it the 'sarcode' (THOMSON, '68 & '70; KENT, '70) or 'sarcodine' (MAR-

SHALL, '75). THOMSON ('68, p. 120) described the Hexactinellidan 'sarcode' as 'small in quantity, very soft, probably semifluid.' MARSHALL (*l.c.*, p. 153) called the same of *Holtenia* 'zähflüssig, hell und durchsichtig' with granulation, from which condition that of *Hyalonema* should have differed but little. These remarks, so far as they go, are essentially in accord with my conception of the nature of Hexactinellidan trabeculæ, notwithstanding the fact that those writers at the time had a very vague and incomplete knowledge of the histology of their subjects.

I believe the trabecular system in its entirety corresponds both morphologically and physiologically to the system of collencytes in that simplest form of the sponge connective-tissue, the collenchyme. There is every reason to assume that the said collencytes, at least in certain sponges, anastomose with their branching processes and thus place the various histological elements of the body in protoplasmic continuity (SOLLAS, '88, p. XLIV). In the Hexactinellids, that continuity of the connective-tissue cells is present in an unusually marked degree.

Where is then the intercellular matrix which always occurs in connection with the true connective-tissue? I believe it is totally undeveloped in the Hexactinellida. As a matter of fact, I find in the entire trabecular system no part which in general appearance or in the reaction against staining reagents can be compared to it.

The absence of the intercellular matrix is of fundamental importance, as it goes a long way towards explaining the peculiarities of the Hexactinellidan soft parts. To it, in the first place, are directly due the thinness of the trabeculæ and the extraordinary development in inverse proportion of the lacunar spaces between

them. It accounts in part at least for the pronounced state of protoplasmic continuity shown by the connective-tissue cells, for there exists no other tissue to participate in bringing about the connection of parts. It also makes intelligible the extension of the lacunar spaces to such an extreme degree that nearly the entire external surface of the chamber-wall is directly exposed to the incurrent water, which fact affords a necessary condition for the opening of prosopyles at all available places between the choanocytes, without however affecting the continuity of these as a layer. Further, may it not be that the connective-tissue matrix, when developed, requires an epithelial limitation against the external world, and that by the absence of the former, the differentiation of the latter is dispensed with in the Hexactinellida? I make this of course as a mere suggestion.

A knowledge of the developmental history of different parts in the Hexactinellid body will be felt by all to be a great desideratum. All that I know at present of the embryology is connected with the larva of two Rossellid species which I have described under the names of *Vitrollula fertile* and *Leucopsacus orthodocus* (IJIMA, '98,). The larva will be described in details under these species, accompanied with figures. Here let it be mentioned that in its early developmental stage, it is spherical, covered externally by a flagellated cell-layer, and contains internally a mass of cells. Remarkable is the fact that the first spicules, which arise already in such a stage in the periphery of the internal cell-mass, are stauractins. The fuller developed larva is spindle-shaped, being thickest towards one end. I think this observation sufficiently warrants me in making the general statement that the Hexactinellidan larva, as regards the arrangement of its

cellular elements, is essentially similar to that of Monaxonid sponges. As to its metamorphosis, not a fact has come under my observation and I shall have to be contented with speculations, guided by our modern knowledge of sponge embryology.

After the Hexactinellid larva has attached itself to some foreign object, the flagellated cells of the external layer should be expected to sink somehow into the internal cell-mass and within this to form the *Anlage* of the chambers.* We may presume that these are arranged side by side in a sort of layer, the chamber-layer, which surrounds the central portion of the original internal cell-mass and at the same time is itself surrounded externally by the peripheral portion of the same. Suppose the cell-mass, both within and without this chamber-layer, becomes lacunose, the lacunæ breaking through on the external surface, we should have the internal and the external trabecular system. An interruption in the chamber-layer puts the lacunæ in the two systems into direct intercommunication, and such a spot may mark the position of a future osculum (see p. 105). If, in addition, the lacunæ undergo certain local expansions,—the one such expansion in the center, as the incipient gastral cavity, being the widest,—we should have a young Hexactinellid essentially agreeing in the arrangement of its soft parts with the little *Lanuginella pupa* figured by F. E. SCHULZE in the Challenger-Report, Pl. LIII, fig. 5. Thus, it is not difficult to derive the structural plan of Hexactinellids, peculiar though it is in several

* In view of the apparent presence of chambers before the immigration of the external flagellated cell-layer in some Monaxonid larvæ, and of the results arrived at by R. EVANS (Quart. Jour. Micr. Sc., n. s., vol. 42, pt. 4) in *Spongilla*, the possibility of certain other cells, which have always lain in the internal cell-mass and which have preserved the blastomeric character, giving rise to chambers under certain circumstances, may not be excluded.

respects, from the larva by the same general course of development known in other sponges.

While it must be admitted that there exists a general agreement between the Hexactinellida and other sponges in the histological elements which should differentiate themselves from the internal cell-mass of the larva, the apparent non-development in the former of the connective-tissue matrix but especially of the pinacocytes—admitting it to be the fact—offers a very grave matter for our consideration. Are the naked syncytial trabeculæ to be considered as the result of degeneration or as representing the primitive condition of the sponge connective-tissue? Against either way of thinking, the very high degree of organization manifested in the spiculation may appear, from a general point of view, to stand more or less opposed. Nevertheless, I hold it possible that the spicules take their own course of development and complication irrespective of the differentiation of the pinacocytes or of the true connective-tissue. At any rate, their formation is known in many sponges (the Hexactinellida included) to begin at a very early larval period, when the internal cell-mass is still in a quite indefinite state of histological differentiation; and I am inclined to see in the naked syncytial trabeculæ of the Hexactinellida simply a representative of the primitive mother-tissue, from which both the connective-tissue cells and the pinacocytes of other sponges have later differentiated themselves,—a structure, which may be said to represent both these kinds of cells at once. In favor of this view seems to stand in a measure the fact that the results of modern embryological researches tend to show the origin of the flattened epithelium from the same category of larval cells as the connective-tissue (Maas, Minchin, Evans).

If I am right in the above assumption, the Hexactinellids are to be regarded as a group of sponges, which have undergone a far-reaching development and differentiation in the spicules, but have remained in a primitive condition so far as certain points in the soft parts are concerned. How far this view, which is of great consequence to the systematic position to be assigned to the Hexactinellida, will be borne out or contradicted by a more extended knowledge, remains to be seen.

Cells in connection with trabeculæ.—As such are to be mentioned in the first place the small cells to which reference has been already made under the name of 'archæocytes.'

Archæocytes.

(Pl. V, figs. 36, 37, 39, 43; *arch.*).

This term was, so far as I know, first used by Sollas ('Sponge' in the Encyclopedia Brittanica) as an equivalent for amœbocytes. I hold it exceedingly probable that the cells now under consideration correspond both morphologically and physiologically to the amœbocytes of other sponges. However, being in want of definite knowledge as to whether they are similarly capable of amœboid motion, I have preferred to designate them by a term of more indifferent signification in that regard. I believe, at any rate, that in the archæocytes of the Hexactinellida we have a kind of cells which remain in a low state of histological and functional differentiation, retaining to a certain degree the blastomeric character, and which give rise in the adults at times to the thesocytes and at times to reproductive elements.

The archæocytes in *E. marshalli*, and also in many other

Hexactinellid species as will be demonstrated in the course of this series of Contributions, are spherical or approximately so ; sometimes they are ovoid and, when several lie close together, they may by mutual pressure approach a polygon in shape. In diameter, they measure only 2–3½ μ, rarely as much as 5 μ. The variation in size is mainly due to the greater or less quantity of the cytoplasm which is on the whole sparingly present, being represented by a thin layer around the nucleus. The outer contour of the cell is even and distinct, without any indication of the presence of an investing membrane.

The cytoplasm appears nearly homogeneous. Osmic acid slightly browns it. In specimens hardened with corrosive-sublimate or with absolute alcohol, it takes up coloring matter very well, so that the outline of the nucleus within is somewhat obscured. If this fact is considered together with the smallness of the cells, which are often of nearly the same size as the trabecular nuclei, there ought not to be much wonder if the cells should be thrown together with the latter under the nuclei, instead of being recognized as complete cells. In fact, in my earlier notes and sketches concerning not only *E. marshalli*, but also a number of other species in which I later recognized their true nature, I find them put down as nuclei ; and I venture to say that F. E. Schulze possibly fared similarly in his study of *Schaudinnia arctica* (see *ante*, p. 159). Examined under an immersion system in successful preparations, the cell-body stands out as distinctly as I have represented it in Pl. V, figs. 37 and 43, inclosing an indubitable nucleus which in its turn contains darkly stained chromatic bodies. Whereas, if seen under only a moderate power, the entire cell-body might easily pass for a nucleus and the real nucleus for a chromatic inclosure.

The archæocytes are apparently simply attached to, or suspended by, the trabeculæ. At other times, they are seen adhering to the outer (incurrent) surface of the membrana reticularis. From their shape and the manner of their occurrence, it is out of question that we have to do with epithelial cells.

There seems to exist a certain limitation to the sphere of their distribution. I do not remember having ever met with them in the dermal or the incurrent canalar membrane, nor in the entire inner trabecular system. If they occur at all in these parts, it must be exceedingly seldom. On the wide-stretched trabeculæ running in the wider incurrent spaces, they are found only here and there sparingly and at irregular intervals. They are seen attached to the trabeculæ mostly singly, at times two or three in close succession. In proximity to the chambers they become more common and are usually quite abundant on the outer surface of, as well as in the narrow incurrent interspaces between, the chamber-walls (Pl. V, figs. 36, 37, 43; *arch.*). Here they occur either solitarily or in irregular groups of two, three, and so on, up to tens and in certain positions even to hundreds or thousands. But the usual size of the cell-groups, as it presents itself fairly constantly on all chambers in irregularly scattered distribution, is small, consisting of, say, not more than about twenty or thirty cells. In Pl. IV, fig. 28, I have indicated such small groups of archæocytes by irregular dots on the chambers (see also Pl. VIII, fig. 29). In these small groups the cells are usually, though not always, found arranged side by side in a single layer, lying flat upon the chamber-wall. It is also the rule that we meet with the archæocytes, whether lying singly or in patch-like groups, in greater abundance where the opposite walls of any two contiguous chambers approach nearest

to each other, than at other places which face a wider interspace (see Pl. V, fig. 43).

The variously sized, flat patches of archæocytes may lie so close against the chamber-wall, apparently closing up the prosopylar meshes in such spots, that in surface views (fig. 37) and often also in optical sections of the wall, they appear to constitute a part of it. But such is not really the case, as can be distinctly made out in many places in specially good sections (fig. 43). The flagellated membrana reticularis runs uninterruptedly alongside the groups.

I have not observed karyokinetic figures in the archæocytes. Nevertheless, many of these are apparently undergoing multiplication, especially in the immediate neighborhood of chambers. This is indicated by the fact that in some exceptional cases two or even three nuclei have been found inclosed in the same cell-body, and also by the great diversity (from only two cells upward) in the size of the archæocyte-groups.

The growth of the latter may take place not only by cell-division of their cells but also by fusion of originally separate groups. For, not infrequently small groups consisting of as yet a very small number of cells lie so near to one another that, should they continue to grow by cell-multiplication, they must soon come into contact. There also exist somewhat larger groups whose irregular shape strongly suggests their origin by such a union of two or more originally separate groups. These facts make me believe that the archæocyte groups or masses are not necessarily to be considered as derived each from a single mother-cell.

As already indicated, the archæocyte-groups, generally flat and small, attain a very considerable size in the deeper parts of

the choanosome in the parietal ledges as well as in the general sponge-wall. After the cells have increased to a certain number, they no longer arrange themselves in a layer but begin to heap up in solid and compact masses. At first the shape of such masses is rather irregular, conforming more or less to that of the intercameral space in which they are situated. With continued increase in the number of the cells and consequently in the size of the mass, the latter assumes a roundish, oval or broadly lobose shape, measuring up to 100 μ or more across. An exceptionally large mass that I met with was oblong in shape and measured 230 μ by 150 μ. The number of cells in such a large mass must amount to tens of thousands.

The above masses vary somewhat in their frequency in different specimens; on the whole, they are common in the positions indicated in all large individuals. On stained sections, when seen under a low power, they are very conspicuous on account of their being strongly colored and forming compact bodies of various sizes and shapes, situated among the chambers (Pl. IV, fig. 28, *a.cl.*). They appear to consist of deeply stained, uniformly small spherules, densely packed together. Under a very high power of the microscope, the spherules prove to be the archæocytes. The outer surface of the mass is tolerably even; the greater part of it presses apparently directly upon the walls of the adjoining chambers. Where it is exposed to the incurrent lacunæ, it seems to be covered by simply a layer of cobweb-like trabeculæ. A continuous follicular envelope does not exist.

Whether all the smaller archæocyte-groups on the chamber-wall in more peripheral parts of the choanosome are destined to form eventually such large masses as I have just described, I do not know. Probably they are. In small and young specimens

the groups, if already formed, are always quite small and not numerous. So that, it may safely be concluded that their increase in number and their massive development take place along with the sponge's advance in age.

I believe the congeries of archæocytes are of quite general occurrence in the Hexactinellida. At any rate, I have met with them, as they occur in small patches on the chamber-wall, alike in a number of genera representing the different Lyssacine and Dictyonine families, and it seems to me somewhat strange that F. E. SCHULZE has omitted to indicate them in so many of his figures of the chambers in the Challenger-Report (except in his pl. LXII, figs. 7 & 8), though they were evidently seen by him in some cases (see below).

The larger archæocyte masses seem to have been noticed by some of the earlier investigators. BOWERBANK ('62, p. 817) mentioned that '*Iphiteon panicea* VAL.' propagates by means of 'gemmules' which he figured badly (*l. c.*, pl. XXXIV, figs. 17 & 18; also Mon. Brit. Spong., vol. I, pl. XXV, figs. 340 & 341). Later, the same writer ('75, p. 506; pl. LVI, fig. 3) again found in *E. aspergillum* a considerable number of 'gemmules' dispersed amidst the tissues and which were of various sizes and closely resembled the same organ found by him before in '*Iphiteon panicea*.' It seems to me probable that the 'gemmules,' in *E. aspergillum* at any rate, are the masses of archæocytes, although nothing respecting their composition can be gleaned from the works of BOWERBANK.

MARSHALL ('75, pp. 153, 157) described peculiar oval bodies which were found in *Dactylocalyx*, *Sclerothamnus* and *Hyalonema* and were considered by him to be the same as Bowerbankian gemmulæ. Here again I hold it likely that MARSHALL had before

him nothing else than the archæocyte congeries. That writer did not find the same bodies in *Semperella*, *Euplectella* and *Holtenia*; probably in the specimens he had of these genera they were, considering the methods he pursued in his study, simply not sufficiently developed to attract his attention.

F. E. SCHULZE's Challenger-Report contains but little matter which seems to be referable to the archæocytes. And yet undoubtedly to be considered as these are the groups of small cells figured by him as lying upon the chamber-wall of an undetermined ?Crateromorphid (*l. c.*, pl. LXII, figs. 7 & 8). Referring to these cells the text simply says: 'Small groups of round cells occasionally occur, but their import is not known' (*l. c.*, p. 24). Again, SCHULZE must have had before him the same cell-groups as he made the following mention under *Farrea occa* (*l. c.*, p. 285): 'In many cases the external surface of the chamber-wall exhibits numerous groups of small, crowded cells, with nuclei which stain with special readiness. It is possible that these groups of six to twelve cells are concerned with reproduction; I have at least remarked their total absence in several specimens which contained numerous sperm balls at various stages.' The 'sperm ball,' or 'sperm mass,' herein mentioned and found also in *E. aspergillum* (*l. c.*, pp. 24, 67)—at least in its young stage or as shown in *l. c.*, pl. IV, fig. 6—is, I think, still another thing which is identical with my archæocyte-congeries. However, I do not mean to deny the possibility of some of the congeries being a stage in the spermatogenesis (see anon, under Reproductive Elements).

I have before dwelt at length upon the probability of the archæocytes being represented among the larger and the more oval-shaped of the *nuclei* regarded by SCHULZE to belong to the connective-tissue in both *E. aspergillum* and *Schaudinnia arctica*

(see pp. 154, 159). I will here add, in order to further support that assumption, that the oval and relatively large nuclei figured by SCHULZE on the chamber-wall of *E. aspergillum* ('87, pl. IV, fig. 7) are exceedingly likely to be solitarily disposed archæocytes, as one may judge not only from the position and manner of their occurrence but also from their close resemblance to the elements of the above mentioned 'sperm-mass' shown by SCHULZE in another figure (fig. 6) on the same plate. As to the groups of 5–20 nuclei found by the same writer ('99*a*, p. 209; 19'*a*, p. 99) on the chamber-wall of *Schaudinnia arctica*, I have already expressed my opinion (p. 159), which therefore need not be repeated.

The relatively massive development attained by the archæocyte congeries and the constancy and frequency of their occurrence plainly point to their high physiological significance. The idea that first suggests itself is that they must be connected with reproduction. And I believe that this in a great measure is the fact; but let me consider this point in my treatment of the Reproductive Elements. Here I should emphasize the fact that the single cells composing the congeries as described above are apparently as yet in no way differentiated from the solitary archæocytes which have given rise to the latter by repeated division and probably also by simple union. The congeries are to be considered as homogeneous accumulations of simple archæocytes, still unsettled, as it were, as to the office they should assume. Considered in this light it is possible to conceive, that they, though representing *par excellence* the *Anlage* of certain reproductive bodies, are under some circumstances capable, as I think they are, of giving rise to certain other bodies which are of service in the preservation of individuals, viz., the thesocytes.

Thesocytes.

(Pl. IV, figs. 23–25; Pl. V, fig. 36; *th.*)

Some facts concerning this kind of cells have already been given *apropos* of the 'Knollen' cells described by F. E. SCHULZE from the trabeculæ of *Schaudinnia arctica* (p. 156). Besides that investigator, MARSHALL also seems to have seen the same cells in *Holtenia* ('75, p. 154; pl. XIII, figs. 3–6).

In general the thesocytes are plump-bodied but rather irregularly shaped cells inclosing fat-like granules or globules, amongst which the nucleus is always demonstrable. In the details of their appearance they vary somewhat in different species. For example, in *Rossella longispina* IJ. the fat-like substance appears to fill up the cell in a single mass (measuring, say, 10–20 μ across), pressing the small nucleus against the thin investing membrane. In *Rhabdocalyptus victor* IJ. and *R. capillatus* IJ., it is accumulated in the form of a small number of variously sized spheres, which take up nearly the entire space of the cells (7–15 μ, sometimes 20 μ, in diameter); together with such cells there occur others in which the reserve-matter is apparently breaking up or has been nearly entirely resorbed. *Acanthascus cactus* F. E. SCH. shows the thesocytes in unusually large numbers, scattered on the trabecular beams as well as on the dermal and gastral membranes. They may be described as compact masses (measuring 8–20 μ across) of small and uniform-looking spherules (about 2 μ in dia.), which are well preserved in all hardened specimens, generally concealing the nucleus amongst them. Here again we occasionally meet with such thesocytes as have the spherules evidently in different stages of disintegration and of resorption. This process consists in the

breaking up of the spherules into irregular granules, which finally disappear, leaving behind pale-looking, collapsed relics of the cells with plainly visible nuclei.

Of much the same general appearance as the thesocytes known to me, seems to be the corresponding cells ('Knollen' cells) of the Arctic forms studied by SCHULZE ('99 *a*; 19'*a*). In respect of microchemical reactions of the inclosed reserve-matter and also in the changes undergone by this, there exists a tolerably close agreement not only among the Hexactinellidan thesocytes themselves but also between them and those of *Thenea* as described by SOLLAS ('88, pp. XXXIX-XL).

In *E. marshalli* the thesocytes occur partly solitarily and partly in massive groups.

The solitarily lying thesocytes are present in a quite sparing quantity, being found only here and there without regularity upon both the external and the internal trabeculæ (Pl. V, fig. 36, *th.*). On the dermal as well as the gastral membrane there are occasionally found irregularly shaped cells containing a variable number of coarse and loose granules in the cell-body. One such cell is represented in Pl. IV, fig. 23, *th.* I believe we have here to do with old thesocytes in which the resorption of the fat-like bodies has advanced to a great degree.

On pp. 87–88, I have described irregularly shaped spots of a deep orange-yellow color, visible in the choanosome of fresh *E. marshalli*. Microscopical examination showed that these spots consisted of thesocytes closely packed together. I consider these cells as identical with those found isolatedly on the trabeculæ not only because of the agreement in appearance, but also on account of the fact that I have found signs of the former loosen-

ing themselves and becoming dispersed from the congregated state. The groups are evidently not the result of the coming together of the thesocytes from neighboring parts, for I have been able to trace back their origin to certain archæocyte congeries described in the last chapter. The archæocytes develop into the thesocytes by gradually accumulating the fat-like bodies in the protoplasm, whereby the cells grow considerably in size. Pl. IV, fig. 24 illustrates the transition of a mass of archæocytes into that of thesocytes. On the left of that figure are seen a number of archæocytes still in the original state ; toward the right they pass into thesocytes by an uninterrupted series of intermediate stages.

As before mentioned, the orange-yellow spots, i.e., the thesocyte-masses, are very variable in size. Some are quite minute, while others may be as large as half a millimeter across. This indicates that the transformation into thesocytes may take place at any stage in the growth of archæocyte congeries. It is probable that even a solitary archæocyte may develop into a thesocyte; but of this I have no direct evidence. The thesocyte-masses were not noticed by me in any other species than in *E. marshalli*, and it may be necessary in the former cases to assume that the thesocytes there present in scattered distribution arise from similarly circumstanced archæocyets.

The question, whether all the archæocyte congeries in *E. marshalli* are destined to undergo the above development, is, I believe, to be answered decidedly in the negative. (See *ante*, p. 172, & anon under Reproductive Elements). While the process is to be called perfectly normal, it appears to represent a special case of the functional and morphological differentiation of archæocytes, taking place under certain physiological conditions, which are difficult to determine but which at all events

involve the nutritive state, local or otherwise, of the soft parts.

It now remains to give notes on the thesocytes of *E. marshalli* based on my own observations of them, which have been chiefly made on those composing the orange-yellow spots.

While some of these cells are but little larger than archæocytes, the majority measure about 7 μ across, sometimes as much as 12 μ. When liberated from their mass in the fresh state, the cells are spherical in shape. A membranous envelope is apparently wanting. The nucleus, which differs in no way from that of archæocytes or of the trabeculæ, is always easily demonstrable by staining (Pl. IV, figs. 24, 25).

The fat-like spherules inclosed in the cell-body are present sometimes in quite small numbers but in most cases tolerably numerously, pressing the finely granular protoplasm into a thin enveloping layer and into fine partitions between them. They are of various sizes within the same cell. During the teasing they are easily freed from the cells. Under the microscope, the single spherules appear pale-yellowish, perfectly homogeneous and moderately refractive. They are not firm solids but are evidently of a soft, perhaps even fluid, nature, to judge from the manner in which they change form or fuse together when subjected to pressure under the cover-glass.

In the fresh condition, the spherules can not be colored at all or but very faintly by eosin, acid-fuchsin, Bleu-de-Lyon or methyl-green. However, they greedily take up methyl-blue. Iodine renders them brown, which color grows simply darker on the addition of sulphuric acid. Osmic acid blackens the orange-yellow spots made up of the thesocytes; but when the latter are examined singly under the microscope, the inclosed spherules or

remnants of the spherules appear simply of a darkish hue. Weak formalin extracts the yellowish coloring matter of the spherules but preserves them in their original form. When acted upon by alcohol, their color likewise dissolves away, while their shape, evidently owing to shrinkage, becomes more or less irregular, losing its homogeneous appearance and often producing vacuoles within.

In sections of specimens which had been fixed with corrosive sublimate or with strong alcohol, I found the cells contracted to an irregular or tubercular shape (Pl. IV, fig. 25). In most cases the spherules had wholly disappeared, leaving behind vacuole-like empty spaces once occupied by them. But their disappearance was in many cases not complete, there being left in these cells a greater or less quantity of the matter in the form of irregular clumps, conglomerates or granules. Remarkable is the fact that occasionally some or nearly all of the spherules in a cell are found to even retain their original form and arrangement. It may be that certain spherules are of a somewhat firmer consistence than others and are thus capable of resisting to a greater or less degree the destructive influences of the hardening reagents.

F. E. Schulze ('99*a*, p. 207) has found, in the three Arctic species studied by him, the 'Knollen' well preserved in all specimens which were first treated with sublimate solution, but more or less completely dissolved away in those which were hardened in strong alcohol from the first. In *E. marshalli* the appearance of the thesocytes, as seen in sections cut after the usual processes of dehydrating and paraffine-imbedding, seemed to be much the same, irrespective of the different reagents into which the specimens were first thrown.

In view of the usually well preserved state in which we meet with the thesocytal spherules in sections of *Acanthascus cactus*, *Rhabdocalyptus capillatus*, &c., before mentioned, it seems necessary to assume a certain difference in their properties, physical or chemical or perhaps both, at least between those of certain species. After being hardened, the spherules or their residue are shining, strongly refractive and of a yellowish color. Ether or chloroform does not dissolve them away. They now take up intensely such stains as acid-fuchsin, eosin, hæmatoxylin, &c. Borax-carmine colors them only to a moderate degree; occasionally it leaves them nearly or quite uncolored, the variation being due I think, to certain varying conditions connected with the state of the constituent matter.*

As to the chemical nature and physiological significance of the thesocytal spherules, F. E. SCHULZE ('99*a*, p. 207) stated: 'Wahrscheinlich handelt es sich um ein Stoffwechselprodukt, ähnlich dem Glycogen, vielleicht auch um eine dem Amylum oder dem Fett vergleichbare Reservenahrung. Doch möchte ich besonders betonen, dass es nach dem Ausfall meiner mikrochemischen Reactionen weder Glycogen noch Amylum noch Fett sein dürfte.' I completely concur in this opinion. Probably the substance is of an albuminoid nature, as was suggested by Sollas ('88, p. XL).

* A pronounced case of the inconstant behavior of thesocytal spherules toward stains is offered by *Acanthascus cactus*. Colored with acid-fuchsin after hardening, all the spherules in some thesocytes are intensely stained, while those of others in the same preparation are not at all or but faintly stained. Methyl-blue gives similar results. Combination-staining with the two kinds of stains just mentioned, or with hæmatein-alum followed by either eosin or acid-fuchsin, gives beautiful preparations in which the thesocytes show the spherules deeply stained red in some and blue in others. I am inclined to think that this power of selecting different stains is probably due to some inconstancy in the nature of the spherules at different stages of their existence.

Reproductive Elements.

All that we know about the ova and spermatozoa of the Hexactinellida is the little that was reported by F. E. SCHULZE ('80, '87) from *E. aspergillum*. As his remarks in this connection are brief, I may here quote them in full:

'In the connective substance, finally, occur the genital products, the sperm masses and ova, in more or less abundance, and usually in the same individual. The sperm masses, both in young and mature stages, are exactly like those of other siliceous Sponges, such as *Reniera*. In their immature form the ova are indistinguishable from connective-tissue cells. They subsequently increase in size and develop refracting yolk granules, and exhibit a very characteristic aspect owing to the enlargement of the nucleus. It is remarkable that in the adult (0.3 mm. in diameter), irregularly roundish ova of *E. aspergillum*, along with which ripe sperm masses also occurred, the nucleus was situated not in the ovum itself, but lay free in a superficial depression into which it had been squeezed. This expulsion of the nucleus was probably the result of the drastic preservative treatment.

'It is curious that I have never been able to discover any distinct segmentation stages. It would not, however, be justifiable to jump to the conclusion that the ova leave the body of the Sponge as such, and undergo subsequent development outside the mother organism.' (F. E. SCH., '87, p. 24).

The numerous sperm-balls, and also ova of different sizes (up to 300 μ in dia. and 'filled with round yolk-granules'), were found both in the inner and in the outer trabecular frame-

work, in some of the specimens of *E. aspergillum* examined by SCHULZE (*l. c.*, p. 67).

The same investigator also stated that he had discovered numerous sperm balls in various stages of development in several specimens of *Farrea occa* (*l. c.*, p. 285).

It is somewhat surprising to me that, although the different Hexactinellid species histologically studied by me are not few in number, yet scarcely a single case, in which either of the sexual products was indisputably developed, came under my observation. In the case of *E. marshalli*, I have made special search for them in numerous specimens which were obtained at various dates extending over the four seasons of the year; but the results were quite unsatisfactory, as will be seen in the sequel.

As regards the *male* elements, I must say I am simply quite in the dark.

I should mention here certain peculiar structures—small, irregularly rosette-like groups of minute, radially arranged, rod-like bodies (Pl. V, fig. 44)—which at times caused me to suspect that they might represent a stage in the spermatogenesis. Exactly the same structures had also been discovered by me in a specimen of *Acanthascus cactus*. In *E. marshalli* I have found them in sections of a single specimen, which was killed with absolute alcohol, Jan. 4, 1896; they seemed to be present only in the interior of chambers, sticking to the residue of the flagella. The groups are somewhat variable in size (measuring about 3 μ in average dia.) and considerably so in the number of the rod-like bodies in each. The single rod-like bodies are thin and usually somewhat narrowed at both ends; they are less than 2 μ in length, some being appreciably thicker than others. Their

substance is apparently homogeneous and is about as deeply stained by borax-carmine as the chromatin of ordinary nuclei. Their exact relation to one another at the central ends is difficult to make out. No trace of parts comparable to the tail of spermatozoa can be discerned at the outer ends. Nor have I been able to discover developmental stages of the single bodies or of the groups. Particularly the not uniform appearance of the rod-like bodies, and the indefinite number of them in each group, make me, after all, decidedly disinclined to explain them as the heads of developing spermatozoa. More probably I have had before me simply colonies of a certain low organism, perhaps parasitic in nature.

In *E. aspergillum*, F. E. SCHULZE declares to have observed both *young* and *mature* sperm-masses. It is to be regretted that neither of them was specially described. The cellular 'sperm-mass,' shown in his pl. IV, fig. 6 (Chall.-Report), is evidently meant for a young stage, and as before indicated (p. 171), I have scarcely a doubt that such young 'sperm-masses' of SCHULZE belong under what I have called archæocyte-congeries. Nevertheless, SCHULZE may be perfectly right in his interpretation; for, there is no ground to deny the possibility that some, but not all, of the single-standing archæocytes represent, or are destined to differentiate into, the spermatogonia, which, after repeated division, should finally give rise to masses of ripe spermatozoa. But, before this can be accepted as the fact, further evidence has yet to be adduced.

As to the *female* elements I have likewise been able to derive no definite knowledge from my own observations. I can do no better than to describe, for what they are worth, two cases

of Hexactinellids in which I have found unusually large cells, more or less ovum-like in appearance.

The one case occurred in a small Rossellid species which I have described under the name of *Leucopsacus orthodocus* (IJIMA '98, p. 42). Of that species I have had only two specimens in all. In one of these, but not in the other, were discovered in some numbers spherical or ovoid, comparatively large cells of 20–40 μ diameter, attached to the trabeculæ or lying apparently free in the lacunar spaces. They had smooth, sharply contoured, external surface. The finely, densely and uniformly granular protoplasm is tolerably well stained by carmine or by hæmatoxylin. The centrally situated and exceedingly conspicuous nucleus is spherical, large ($11^1/_2$–15 μ dia.), intensely stained, and nearly homogeneous in appearance; but at times it shows an obscurely heterogeneous structure. A very wide gap in size and in the appearance of the nucleus separates the cells from the largest archæocyte found in the species, the latter measuring not more than $3^1/_2$ μ in diameter and having a nucleus which usually has a single, refringent, chromatic granule in its interior. Being thus unable to trace the cells back to their origin or to follow their subsequent history, I do not feel that I am in a position to form a judgment as to their real nature. Ovum-like as they appear, the possibility of their being extrinsic, even perhaps a Protozoan parasite, can not be excluded. In the same specimen I have found, as in *Vitrollula fertile* (p. 162), a number of larvæ in different stages of development. This seemed at first to be suggestive of the import of the above-mentioned large cells. However, I have failed to discover segmentation stages, or in fact, any sign of genetic relation between the cells and the larvæ. On the contrary, the origin of the latter seemed to be

traceable to a different source, viz., to the archæocyte-congeries which were commonly met with in both of the specimens I had of the species. I shall return to this point soon again.

The second case relates to a rather small specimen (110 mm. long) of *E. marshalli*, which was killed August 10, 1895, by means of corrosive-sublimate dissolved in sea-water. The specimen had a portion of the wall evidently repaired after an injury by which some of the external ledges had been torn off. Not only in the parts thus restored but also in the old uninjured parts, there were found a number of peculiar, plump-bodied, variously sized cells (Pl. V, fig. 45, *x*.), the like of which I had never discovered in any other specimen. The cells occurred in irregular distribution, in places abundantly, on both the external and the internal trabeculæ as well as on the dermal and the gastral membrane, sometimes also on the apparently naked surface of certain spicules. Less frequently were they met with on the convex external surface of chambers, along with the usual archæocytes. They seemed to be simply adhering to the parts mentioned by a small portion of their surface or by a broad base.

In shape the cells are generally more or less spherical; under certain circumstances they are hemispherical, fusiform or rather irregular. The larger ones measure 10–15 μ, sometimes 23 μ, in diameter,—a size which is on the whole considerably larger than that of the largest thesocyte. The smallest cells are in no way distinguishable from, or are but slightly larger than, the archæocytes, with which they are thus connected by an uninterrupted gradational series of intermediate forms. There can be no doubt that the large cells belong to the sponge and that they take origin by growth from certain archæocytes. I have

noticed that the latter kind of cells were comparatively sparsely present in places where the former occurred in abundance.

An enveloping membrane around the large cells can not be made out. The cell-body (see fig. 45, *x*.) shows a dense, uniform, generally fine but sometimes somewhat coarse-looking granulation, in which single granules are not clearly definable nor particularly refractive. The appearance of the cell is therefore quite different from that of thesocytes. The protoplasm is moderately well stained by borax-carmine or by acid-fuchsin; Bleu-de-Lyon colors it diffusely and faintly, indicating the absence of formed yolk-particles. The well-stained nucleus is distinctly visible; it resembles exactly that of archæocytes or of the trabecular syncytium both in size and in appearance, but differs strikingly in the same respects from the nucleus of the large cells I have described from *Leucopsacus orthodocus*. In rare and exceptional cases, two or three nuclei were observed lying together in the same cell-body. As the latter were yet small and far from having attained their full size, it was out of question to suspect polar globules or the beginning of segmentation in those cases. After the cell has reached a certain size, the nucleus assumes a markedly eccentric or extremely superficial situation,—a fact, which reminds one at once of F. E. Schulze's statements in regard to the position of the nucleus in the egg of *E. aspergillum*. In the present species, the nucleus does not undergo an enlargement with the growth of the cell. In some cells of the largest size, I have been unable to detect the presence of the nucleus and that, under circumstances in which this could not possibly have lain concealed in the granulation. The idea suggested itself that its apparent absence might betoken impending division, but no indication of a karyokinetic figure could be

discerned. Nor could I be absolutely sure that the part containing the nucleus had not been sliced away by the microtome-knife.

Are the above described cells in *E. marshalli* really eggs? Possibly they are, though I know nothing about their subsequent development. While their homology with the large cells that I have discovered in *Leucopsacus orthodocus* is questionable, I hold it fairly probable that in them we have the identical cells which were taken by SCHULZE for the ova of *E. aspergillum*. The little discrepancies between his descriptions and my own may be explained by assuming that only comparatively young stages in oögenesis have come under my observations; whereas, some of those observed by SCHULZE had a diameter more than ten times greater than that in the largest seen by me.

Here let me return to the *archæocyte-congeries*, in their bearing on reproduction in the Hexactinellida. I have endeavored to show that, under certain circumstances, they may transform themselves into masses of thesocytes (p. 174). Of the others that do not undergo development in that direction, there may possibly be some that represent an early stage in spermatogenesis (p. 181). At the same time, I believe that a good part of the primitive archæocyte-congeries are directly and actively concerned in the formation of certain reproductive bodies, asexual or sexual but other than spermatozoa.

From *Rhabdocalyptus mirabilis* F. E. SCH., which multiplies, similarly to *Lophocalyx philippinensis*, by producing small buds on the external surface, F. E. SCHULZE ('99, p. 63) has described as the first *Anlage* of the bud a solid tissue-mass containing small nuclei in tolerably dense and uniform distribution, and

situated in the outermost part of the parenchyme under the dermal layer. On *a priori* grounds, it seems to me nearly certain that that *Anlage* is, or is derived from, an aggregation or congeries of archæocytes, much the same as that which is so commonly found in the deeper parts of probably all Hexactinellida after maturity. The said *Anlage* is incorporated in the newly formed bud, with perhaps a portion of the maternal dermal layer in addition; and, from it should originate by differentiation most of the different soft parts, or at any rate the flagellated chambers of the progeny,—a fact, which is readily conceivable on account of the blastomeric character I ascribe to the archæocytes (pp. 165, 172). Be that as it may, there stands nothing in the way, so far as we know, of calling the above mode of reproduction in *R. mirabilis* asexual budding,* in which process the archæocytes seem to play a very important rôle.

* From the character of the organization of the Hexactinellid body, it is not to be wondered at, if a similar budding should take place in the interior of the sponge-wall, instead of, or in addition to that, on the external surface. As an indication of such an internal budding is perhaps to be regarded a remarkable case of *Staurocalyptus glaber* IJ., in which I found an innumerable number of small whitish bodies, distributed throughout the entire parenchymal mass. On close examination they proved to consist of small, thick-rayed hexactins fused together into an irregular framework, which was traversed by a few parenchymal spicules. The framework, which I call the *basidictyonalia*, is undoubtedly the same as that described by SCHULZE ('99, p. 64; Pl. XIV, figs. 2–6) from the buds on the prostalia lateralia of *R. mirabilis*. It may safely be concluded that a brood of the young had fixed themselves on the parenchymal spicules of the aforesaid specimen of *S. glaber*. The young may have been asexually produced exactly as those of *R. mirabilis*, though not necessarily so. In my opinion, the basidictyonalia is a structure which is formed quite generally in Rossellids and in certain other Lyssacine families evidently under the influence of the hard substratum with which the sponge comes in contact at its base. It has hitherto been generally overlooked, though the particularly small-meshed and most superficial layer of it has long been known through SCHULZE. The little mass of basidictyonalia in both *R. mirabilis* and *S. glaber* is to be regarded as having arisen in relation to the old spicules on which the young had attached themselves. It may therefore be equally developed in all the young irrespective of these having been produced asexually or from fertilized ova. However, under the assumption that the brood in the above case of *S. glaber* originated from eggs, it seems somewhat strange that the ciliated larvæ were prevented from being set at large during the free-swimming period.—Of several *R. glaber* examined by me, the above was the only specimen in possession of a

Somewhat enigmatic is the process by which are formed the bodies unhesitatingly called by me, because of their structure (p. 162), the *larvæ*, in *Leucopsacus orthodocus* and *Vitrollula fertile*. As before mentioned, the larvæ in both these forms were found in different stages of development. Deferring the details of my observation on this matter to a further Contribution, it is incumbent on me to mention here that, in a certain early developmental stage, the embryo is spherical in shape and consists of a compact mass of small cells, which mass is superficially delimited by a layer of cells, whose general appearance is like that of the internal cells, but which show an epithelium-like arrangement. There is as yet no flagellation discernible on the external surface, nor are the first spicules developed in the internal cell-mass. The embryo occupies a position in the incurrent lacunæ between the chambers, being apparently devoid of a special follicular envelope. As a still earlier stage, directly preceding the one just mentioned, there is found a simple cellular mass, agreeing in all respects with the latter except in having no distinct epithelial covering. And, that simple cellular mass is in all appearance nothing else than an advanced stage of what I have called the archæocyte-congeries, of which there exists a series of different sizes, leading down uninterruptedly to the little groups of cells so commonly found on the chambers. At all events, there is nothing else than these compact groups of small cells to which the origin of the developing embryo can be traced back with any degree of probability.

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brood. That this belonged genetically to that very specimen and was not of extrinsic origin, is fairly admissible on the ground of the very large number of young present. The case may be construed as indicative of the fact that the formation of young broods takes place in a short period of time and then in great profusion. The specimen referred to was obtained during the month of May.

To repeat, to me it seems certain that the embryo in a very early stage of its development consists of a small assemblage of uniform-looking cells, which differ in no distinguishable feature from the archæocytes. If the resulting body were something comparable to a bud or a gemmula, I would probably have felt no hesitation in concluding that the cells were really archæocytes, and that we had here to do with a case of asexual reproduction. But, free-swimming larvæ, essentially similar to those developed from ova in other sponges, being at issue, the question whether true ova are not somehow complicated in the cell-mass whence the larva arises, seems to claim to be brought on the tapis, all the more, since our knowledge of the Hexactinellidan ovum is far from being satisfactory.

H. V. Wilson ('94) has made endeavors to show that in certain Monaxonid species (*Esperella fibrexilis*, *Tedania brucei*), larvæ similar in all fundamental respects to those which develop from eggs in other species, arise, exactly like gemmules, in an asexual way. The 'gemmule larva,' as distinguished in genetical relation from the 'egg larva,' develops from a simple cellular mass, which originates by the multiplication and coming together of certain 'mesoderm' cells. I conceive the mode of origin and growth of the archæocyte-congeries in the Hexactinellida to be just the same, and it seems to me not impossible that in the Hexactinellid larvæ which I have seen, we have simply a new case of the 'gemmule larva' or bud embryo.

Serious doubts have been thrown on the accuracy of Wilson's observations concerning the 'gemmule larva' by Maas ('96) and Minchin ('97). Especially the former writer has suggested that the 'gemmule larva' may have arisen from an egg just like any ordinary larva and that Wilson's idea of its

formation probably rests upon a mistaken interpretation of a process of oögenesis.

So far as concerns the archæocyte-congeries of the Hexactinellida, I can confidently state that among the constituent cells in any stage of its growth, there exists not one which, on account of its size or of other external peculiarities, can be recognized as an egg. If it be that so many cells are aggregated for the sake of the nutrition of a developing ovum, this ovum is to be expected to deviate more or less morphologically from the rest as it approaches maturity; however, no sign of such a differentiation is noticeable. Further, all the cells in a congeries, large or small, are tolerably uniformly and compactly packed together, so as to directly touch one another; and where they are somewhat loosely arranged, there is not a trace of any substance between them. So that, I am decidedly against the assumption that some of them are, at any stage of the growth of the congeries, engulfed among certain others as pabulum. If, after all that, a portion or all of the cells in a congeries giving rise to an embryo are still to be looked at in the light of blastomeres that have arisen by segmentation from a single egg-cell, one is driven to the assumption that the original ovum is, like the blastomeres themselves, as small-bodied as, and indistinguishable from, an archæocyte. This would be very remarkable in an ovum; and moreover, under that supposition, it become imperative to deny egg-nature to the large ovum-like cells described by SCHULZE and by myself from *Euplectella*.

It is idle to go into further speculations. From all that I have seen, I am inclined at present to entertain views similar to those put forward by H. V. WILSON in attempting to explain the nature and origin of the larvæ I have discovered in the

Hexactinellida, and to give to the generality of archæocyte-congeries a physiological significance in accordance therewith. However, some important points may possibly have escaped my attention in tracing the origin of the embryo, since the supply of materials for the investigation of the points in question was not as plentiful as might be desired. I should therefore prefer to defer the definite formulation of an opinion until after I have had more opportunities for studying the matter than I have had hitherto.

Summaries of the Histology of E. marshalli.

Chamber-wall:

1. The choanocyte has a flattened, ramified body, containing a likewise flattened nucleus. It possesses a collar and a long flagellum.
2. The collar is narrow, approximately cylindrical, and stands out quite isolated from its neighboring fellows.
3. The ramifications or lateral processes of the choanocyte-body are fused with one another so as to form the reticular membrane.
4. All the meshes of the reticular membrane are open and serve as prosopyles.
5. The reticular membrane has on its external side neither a basal membrane nor a layer of connective tissue to rest upon. In it are inserted only the ends of the external trabeculæ which keep the chambers expanded and in position.

6. Around the large apopyle is a narrow membranous rim, the marginal membrane, which may be said to be an extension of the connecting membrane overspreading the interspaces between the apopyles of chambers arranged side by side.

Trabeculæ :

7. The trabeculæ are thin and irregularly cobweb-like in appearance. They consist of continuous protoplasm with nuclei, and thus represent threads and films of a syncytial nature.
8. A pinacocytal covering is not demonstrable on any part of the trabecular system. It is apparently wanting.
9. The dermal, the gastral and the canalar membrane, as also the membranes mentioned under 6., are adaptations of the general trabecular system.

Cellular elements in the trabecular system :

10. The archæocytes—small cells retaining a blastomeric character—are found on the trabeculæ ; more especially on the outer surface of the chambers, where they form congeries of various sizes.
11. The thesocytes—cells containing fat-like reserve substance in the form of spherules—are usually found quite sparingly on the trabeculæ ; but in places they form massive aggregations, derived from certain archæocyte-congeries by transformation of cells *en masse* into thesocytes.
12. The generality of the archæocyte-congeries is apparently concerned in the formation of certain reproductive bodies (?of an asexual nature).

13. Spermatozoa have not been observed. In a single specimen there were observed comparatively large, ovum-like cells which seemed to arise from isolated archæocytes on all parts of the trabecular system, but not from the archæocyte-congeries.

Development of Hexasters.

Here will be recorded some fragmentary observations in regard to certain developmental stages of hexasters, chiefly of the floricome and the graphiocome in *E. marshalli*. As illustrations will serve Pl. V, figs. 29–31 for the former, and figs. 32–35 for the latter.

Both these hexasters in different stages of development are met with not uncommonly among the trabeculæ of the subdermal region, outside the choanosome. The frequency of their occurrence even in old specimens is explained by the fact that both kinds of the hexasters are being constantly lost, or rather used up, after full development and thus require to be replaced by new formations (see p. 53). Young stages of the graphiocome are by far the more common.

The earliest stage observed by me in the hexaster development was already in possession of the six principals in the usual regular arrangement (fig. 29), but the terminals were not yet even indicated. The said principals were of the same length as in the fully developed state, but appreciably thinner.

In any hexaster, so much of it as consists of the six principals is undoubtedly identical with the ordinary hexactin, the fundamental type of the Hexactinellidan spicules. This is clearly shown by the invariable presence and the extent of the charac-

teristic axial filaments in the principals (see p. 51). It may therefore be said that *a hexaster begins its development as a hexactin*. The terminals are appendages which are later added to the principals (see p. 56).

It is highly unsatisfactory that earlier stages than the one just mentioned—stages which might have shown the mode of the first formation of hexaster principals and therefore of hexactin rays—have not been discovered. I should think it not unlikely that these might be found to originate each as a separate sclerite, as was so beautifully shown by MINCHIN ('98) to be the case with the rays of triradiates and quadriradiates in the Calcarea.*

The hexradiate principals, during the entire period of development of both the floricome and the graphiocome, are imbedded in a body of protoplasmic substance inclosing a crowded number of nuclei. This nucleated substance may not improperly be called the *scleroblast-mass*, for reasons which I think are obvious. At first, so long as the terminals are yet undeveloped or are very short, the mass may be said to present a more or less octahedral shape, with somewhat concave surfaces and with rounded corners (figs. 29, 30, 32). In it the three axes of the principals are disposed similarly to the axes in a crystal octahedron, the outer ends of the principals coming up very close, but I think normally not quite, to the surface at the six rounded corners. The mass may otherwise be described as having its surface raised into six, radially directed, hump-like protuberances by the six principals contained within. Later, after the terminals have

* I may here once more call attention to the facts, mentioned before, viz., that the first spicules which arise in the larvæ of *Leucopsacus orthodocus* and *Vitrollula fertile* are *stauractins*, and that these are formed in the periphery of the inner cell-mass in a very early larval stage which *shows as yet no indication whatever of the chambers*, the flagellated cells still forming a covering layer on the external surface. These facts may contain hints of great significance as to the phylogeny of spicules in the Hexactinellida.

considerably advanced in growth, the scleroblast-mass appears at the center of the developing hexasters as a more spherical body, not unlike a berry, on account of the aggregated nuclei (figs. 31, 33, 34).

The protoplasm of the scleroblast-mass is finely granular and is stained in about the same degree as the trabecular plasma. The contour at the external surface is indistinct; sometimes it is tolerably well defined and is found to be either irregular or moderately even. There is never a delimiting membrane in contact with the mass. The numerous, closely packed nuclei do not differ, either in size or appearance after staining, from those of either the trabeculæ or the archæocytes. Not a trace of cell-outlines is discernible around them, which fact makes me believe that the scleroblast-mass represents a syncytium.

Here I am reminded of MINCHIN's ('98) statements with regard to the development of calcareous spicules, of which he says that the formative cells in a sextet appear to *fuse* together at the center, where the first secretion of the rays of a triradiate spicule soon afterwards takes place; and also that the nucleus of the cell, which gives rise to a fourth ray in forming a quadriradiate spicule, may divide, thus forming a *plasmodium*-like investment to the developing ray. Whether the agreement suggested between the state of the formative cells in the Calcarea and that of the Hexactinellida is of any real import, I am not prepared to say.

The number of nuclei in the scleroblast-mass may possibly stand in relation to that of terminal rays in, or to the size attained by, the hexaster to which it gives rise. At all events as a matter of fact, I have found the nuclei most numerous in the

case of graphiocomes, somewhat less so in that of floricomes, and least of all in that of certain oxyhexasters (see anon, p. 199).

The scleroblast-mass remains in its position, unchanged in essential points of appearance, until the development of the terminals is completed. Sooner or later after that, the mass disappears, but whether by atrophy or by dispersal, I have no more means of knowing than I have respecting the source from which it is derived. If it be justifiable to judge from what became known through MINCHIN in the Calcarea, the mass may be referred genetically to the trabecular tissue; and its return to the same after the completion of its special formative function is probably to be assumed.

Certain it seems that during the growth of the terminals no nucleus moves away from its group around the spicular center. At least I could gather no evidence pointing to such a movement. It is true that after a certain period in the growth of terminals, a variable number of nuclei is met with right among, or in close proximity to, these (figs. 31, 33–35). However, they are altogether so inconstant in number and indefinite in position that it is exceedingly questionable if they have anything to do with the building up of the terminals. The nuclei, together with the more or less cobweb-like protoplasm in connection therewith, are probably to be considered, for the greater part at least, as representing the ordinary trabeculæ which have come into a secondary relation with the hexasters.

The terminals in their minute inceptional state (figs. 30, 32) are evidently inclosed quite within the protoplasm of the scleroblast-mass, and are entirely independent of the general trabecular system. It is then a matter of great probability that essentially the same condition persists throughout all the later

stages in the growth of the terminals,—that each growing terminal is completely invested by an extremely thin protoplasmic layer, specialized physiologically at least as the secretive matrix and standing in direct continuity with the scleroblast-mass. Such a layer however could never be clearly demonstrated. Nevertheless, from what I have said, the assumption seems not to be unwarranted that the centrally situated scleroblast-mass is responsible for the development of the entire hexaster. The nuclei in that mass should superintend, as it were, not only the initial formation of the spicule but also the finishing up of the terminals.

Here may be introduced the mention of a thin wall, surrounding the scleroblast-mass but separated from it by a space of some width (see figs.). For the sake of reference I may call it 'the capsule.' It is at first roundish or irregular in shape. As the terminal perianths or sheaves grow in length, it is pushed out by these, soon to become broken through, so that the greater part of them comes to lie without the capsular wall and among the trabeculæ.

The capsular wall, as seen in optic section, appears as an irregular line, much interrupted by breaks in its course. Its substance is of just the same appearance as the trabeculæ. A few nuclei occur on or in it at quite irregular intervals. And, by focussing the microscope so as to view the wall face on, it can be demonstrated that we have to do not with a continuous membrane, much less with an epithelium, but with a thin layer of an irregularly meshed cobweb. Therefore I take the capsule to be only a specially adapted part of the general trabecular system.

A number of trabeculæ join the capsule on the outside and keep it suspended in position. On the inside, a trabecula or

two of extreme fineness are occassionally found to extend from the wall to the scleroblast-mass. Otherwise the space between the two seems to be quite empty.

So far in common as to both the floricome and the graphiocome. Let me now supplement this account by dealing separately with each, referring to the figures I have given in Pl. V.

As to the floricome, the earliest stage I have as yet discovered (fig. 29) shows the ends of the principals only slightly swollen in a knob-like manner. In the total absence of terminals, I have relied on the following peculiarities in identifying it as an incipient floricome, and not as a future graphiocome: viz., the relatively shorter and thinner principals, the somewhat smaller size of the scleroblast-mass, and the number of nuclei in that mass which is smaller than in the case of graphiocomes.

Fig. 30 shows a decidedly more advanced stage in the floricome development. The first rudiments of the terminals are present in a whorl around the outer, convex, terminal surface of each principal.—As to the change in form of the terminals and their perianths during the later stages of development, I have nothing to add to the accounts I have given on pp. 52 & 76.

Fig. 31 illustrates a nearly or quite mature floricome in its relation to the immediately surrounding soft parts. The scleroblast nuclei form a berry-like group at the center. The capsular wall, still plainly recognizable, stretches between the basal parts of the terminal perianths. A number of fine trabeculæ join the terminals, some running between these or across the internal hollow of the perianth. As often as not 1–3 nuclei occupy a position at the fundus of the hollow just referred to, while a few more may be found at indefinite positions in the proximity of

some of the terminals, sometimes lying in direct contact with these.—Among the floricomes which have reached, in their emigration, the tips of dermal hilt-rays, it is quite exceptional to meet with one still retaining the scleroblast-mass, though a number of isolated nuclei are usually found attached to the different parts (fig. 36).

With regard to the graphiocome development, the stage shown in fig. 32 is one of the earliest I have seen. It is at once referable to that form of the hexasters, and not to the floricome, by the somewhat larger size of the scleroblast-mass, by the greater number of nuclei in that mass, by the stouter principals and finally by the planoconvex disc at the outer end of each principal. The outer convex surface of the disc just mentioned is roughend by minute tubercles, which I hold to be the very beginnings of the formation of the rhaphidial terminals.—In a slightly more advanced stage, the microtubercles are developed into spiny processes. Then, the spicule is scarcely distinguishable in form from the portion of an old graphiocome remaining after the loss of the rhaphides (see pp. 53, 77, 101; Pl. IV, fig. 20), except for the fact that in the young state there is invariably present the scleroblast-mass, which is always wanting to old graphiocomes.

Figs. 33 and 34 represent two stages in which the elongation of the terminal sheaf has advanced to different degrees—to about 18 μ length in the one case and to about half the full length in the other. A number of other cases of growing terminal sheaves were measured and I may say I have found these in all grades of length, from only a few μ up to 100 μ and more. The berry-like cluster of scleroblasts as well as the capsule remain visible all the while the graphiocome is growing; afterwards,

both disappear. Interposed between the terminals in a sheaf exists a certain amount of protoplasm, the exact disposition of which can not be determined (fig. 35). The protoplasm contains irregularly distributed nuclei, which are at first few, but increase in number with the growth of the sheaf (figs. 33–35).

Of the oxyhexasters in *E. marshalli*, I rarely came across such as were still apparently far from being complete in the development of their parts. The small, thin-rayed specimen, shown in Pl. IV, fig. 18, represents one such case. There can be no doubt whatever that the general mode of development is here essentially the same as in the other forms of hexasters. Since the few cases I have seen of young oxyhexasters were all found in unstained preparations, I can say nothing in particular about their scleroblasts, which should have been present at the center. However, in certain Rosellids (e. g., *Rhabdocalyptus capillatus* Ij.), I have observed numerous cases of evidently immature as well as nearly mature oxyhexasters in connection with the surrounding soft parts. Unlike the floricome or the graphiocome, a capsular wall seemed to be wanting here, while the scleroblast nuclei were always strikingly few in number. In optical sections, at most only four of these nuclei at a time came into view, more or less regularly disposed in the angles formed by the principals around the central node. Judged by the size of the nuclei and of the extent of space occupied by them, there could be present in each case not more than eight nuclei in all, which maximum number, if regularly distributed, would bring each principal to the middle of every four nuclei. In fact, I think I have observed this regular arrangement in some cases; but I am far from maintaining this with any degree of assurance.

It must be said, that in the above merely a beginnnig has been made in the study of the development of spicules in the Hexactinellida. A series of important questions on the subject remains to be answered in the light of facts which still lie wholly in the dark.

Miscellaneous Notes.

E. marshalli is a species which evinces a very close affinity to *E. oweni* Herkl. & Marsh. But the two species are not to be confounded, on account of the former having a comparatively shorter body in proportion to its breadth, strikingly well developed parietal ledges, and oscularia which, instead of being predominantly diactins, are of miscellaneous forms.

From *E. imperialis* it may be distinguished, in all stages of growth, by the somewhat smaller floricome (p. 103); and in the mature state, by marked differences in the size and shape of body, in the appearance of the parietal ledges and in the fused or unfused condition of spicules in the skeletal framework (see the key on p. 58).

As in *E. imperialis*, here also several instances of the reparation of injuries sustained by the sponge-wall have come under my observation.

In some cases it appeared that a portion of the wall had been torn off and lost, but refilled by regeneration so as to completely restore the continuity of the wall. The regenerated tract can be recognized at once by its generally underdeveloped appearance, which at the edge abruptly passes over into that of the old parts. In it the texture is not so firm as in parts of long standing; the ledges are either quite undeveloped or only

suggested, while the principal parenchymal strands pursue irregular courses instead of being arranged in regularly transverse and longitudinal beams. Of interest is a case in which a veritable sieve-plate, inclosing eleven meshes and exactly comparable in appearance to that at the upper end of the sponge, was formed right in the regenerated tract of the lateral wall. Noteworthy seems another case in which a portion of the superior sieve-plate and of the cuff was incompletely severed and turned up as a free flap, the gap left in the sieve-plate being filled in by an extension of tissues from the lateral wall.

A Stenopid Crustacea, which I identify as *Spongicola venusta* of DeHaan*, inhabits the gastral cavity of *E. marshalli* with tolerable constancy. It is usually found in pairs, a male and a female. Occasionally it has been found single; which of the sexes then prevailed, I have not noticed. Except in very small and young sponges, it is quite rare that the Crustacean inmate is entirely missing.

In the living state, *Spongicola venusta* is a very pretty animal, being transparent and of a light pink color. The female may at once be distinguished from the male by the considerably smaller chelæ and the pale-green ovary visible through the body-wall. Of the same color as the ovary are the eggs attached to the abdominal appendages of adult females.

A frequent companion of the Crustacea in the gastral cavity is an Ophiuron, which I have not identified but which probably belongs to the genus *Ophiothrix*.

* Fauna Japonica. Crustacea. P. 194; pl. XLVI, fig. 9.—Miers, Linn. Soc. Journ. Zool. Vol. XIII, p. 507; pl. 24, figs. 1, 2.—Bate, Chall. Rep. Vol. XXIV, p. 213.

EUPLECTELLA OWENI Herkl. & Marsh.

Pl. VI.

Euplectella, Max Schulze '60, p. 39.
E. Owenii, Herklots & Marshall '68.—Marshall '75, p. 189, figs. in pls.—Marshall '76, p. 128.—*E. Oweni*, Schulze '86, p. 38.—*E. Owenii*, Schulze '87, p. 78; pl. vi, figs. 1, 2.—*E. oweni*, Schulze '95, pp. 29, 48.

An elaborate description of this species was first given by Marshall ('75,) from his study of six specimens most of which, known to have been brought from Japan by Major v. Siebold, were preserved in the Leyden Museum. I presume the specimens were collected by v. Siebold in the waters of Kyūshū. F. E. Schulze has also contributed in the Challenger-Report an excellent account of a specimen, probably the one,* which was procured by Dr. Döderlein at Shimonoseki, a town at the entrance to the Inland Sea from the Corean Channel. The species therefore may be said to be one of the best known in the genus.

In the waters near Sagami, it has as yet never been met with. Whereas, I have had opportunities to examine several specimens which have all come from Kyūshyū or from the neighborhood of that island, as did probably all those previously known.

The first specimen I came across was a dilapidated one which was exhibited, together with red corals, &c., in the Fourth Industrial Exhibition, held 1895 at Kyōto. The exhibitor was

* Mentioned in Döderlein's letter quoted by Schulze in the Challenger-Report, p. 2. For the systematic position of the second specimen mentioned by Schulze under *E. oweni*, *l. c.*, p. 81, see p. 59 of this Contribution.

a coral-fisherman in the Province of Tosa, Shikok; but it is doubtful if the specimen was really obtained in the sea off that province. It was subsequently donated to the Science College by Mr. MIMATS into whose possession it had come.

To my friend, Mr. H. NAKAGAWA, then professor of natural history in the Higher Middle School of Kumamoto, I am indebted for a gift of four specimens, which, though all in a bad state of preservation, have supplied ample materials for my study of the structure. Mr. NAKAGAWA had found them in the possession of two families in Fukuoka, a city on the north-western coast of Kyūshyū.

Early in 1899, Mr. ALAN OWSTON of Yokohama showed me a beautifully preserved specimen of the species, purchased for him by Mr. BLACK in Shimonoseki. With the kind permission of the owner this specimen is shown in Pl. VI, fig. 4. A few weeks later, Mr. OWSTON succeeded in securing in the same city another but less perfect specimen, said to have been originally obtained near Tsushima. This was graciously presented to the Science College.

On two occasions in 1889–1900, Mr. N. ŌNO of the Botanical Institute, Sc. Coll., received from a friend residing in Shimonoseki four specimens, which were with ready willingness donated to the Science College. One of them is the largest I have ever seen; it is shown in Pl. VI, figs. 2 & 3.

Finally, Mr. KOMEYAMA has put at my disposal five beautiful specimens preserved in spirit, which were received from one Mr. M. HISADA of Izuhara, Tsushima. They were collected off the villages of Kuta and Ofunakoshi, on the south-eastern coast of the island just mentioned.

The localities whence came probably all the known speci-

mens of *E. oweni*, as well as much information supplied me by friends*, sufficiently establishes the habitat of this species to be Southern Japan, particularly the waters of the Corean Channel to the north-west of Kyūshyū.

With respect to the characteristics and structures of the species, I have but little of importance to add to what is already known.

General Characters.

The body is straight, phallus-like. The broadest part is usually in the lower half; frequently the greater part of the body presents a nearly uniform breadth. Appended is a list of measurements of 17 specimens including not only those studied by me but also those which had been definitely measured by previous writers.

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*In reply to inquiries made for my sake, several years ago, by Mr. S. Hattori, then teacher of natural history in the Karats Middle School (Prov. Hizen), certain localities in the Genkai Sea (NW. of Kyūshū) were mentioned as the places where the Euplectella is now and then hauled up by the hooks of the long-lines used in the fishery of the bream (*Pagrus*). He reports: 'The bream-catchers hail from Nagahama and vicinity in the Prefecture of Hiroshima, and are accustomed to fish far away from the coast at a depth of 30–50 *hiro*. It is possible that by encouraging these fishermen the Euplectella might be secured. I was told that in this way Mr. M. Kanamar, residing on Kabeshima (a small island not far from Karats), came at one time into possession of seven specimens, varying from about two inches to a foot in length; so that, the species does not seem to be rare after all.'—Moreover, more than one informant had pointed out to me the neighborhood of Tsushima, in the Corean Channel, as the Euplectella locality, the truth of which information has subsequently been borne out by the specimens received by Mr. Komeyama from that island.—The specimens which were presented by Mr. Ōno to the Science College were accompanied by a note, written by the fisherman who is said to have originally obtained them, to the effect that they were brought up hanging to the bream-line at a spot about 80 kilometers to WSW. of the southernmost end of Tsushima and from a depth of approximately 120 *hiro*.

Captain Ōsumi, of the Ōsaka Mercantile Steamship Company, has informed me that in his native province, Suwō, Euplectellæ are well-known objects, being considered as indispensable to the marriage ceremony (see anon under Misc. Notes), and that he used to think that they were fished up near Oshima, close to the coast of that province, in the Inland Sea and not far distant from Shimonoseki.

Spec.	Total length, excl. of basal tuft.	Breadth at the broadest part, ledges incl.	REMARKS.
	mm.	mm.	
A	110	16	Mr. KOMEYAMA'S specimen.
B	117	24×21	„ „ „
C	120	35×30	Measurement given by SCHULZE (**'87**).
D	138	35×28	Mr. KOMEYAMA'S specimen.
E	152	35×31	Sci. Coll. Mus.; pres. by Mr. Ōno.
F	160	†30	„ „ „ „ „ „ MIMATS.
G	*165	†41	„ „ „ „ „ „ Ōno.
H	180	34×30	„ „ „ „ „ „ „ Pl. VI, fig. 1.
I	180	45×35	Mr. KOMEYAMA'S specimen.
J	204	34	Mr. OWSTON'S specimen. Pl. VI, fig. 4.
K	*220	†37	Sci. Coll. Mus.; pres. by Mr. NAKAGAWA.
L	220	40	Mr. KOMEYAMA'S specimen.
M	226	37	Measurement given by MARSHALL (**'75**).
N	240	†45	Sci. Coll. Mus.; pres. by Mr. OWSTON.
O	*250	†40	„ „ „ „ „ „ NAKAGAWA.
P	311	46	Measurement given by MARSHALL (**'75**).
Q	360	62×48	Sci. Coll. Mus.; pres. by Mr. ŌNO. Pl. VI, figs. 2 & 3.

* Sieve-plate wanting, and therefore excluded in measuring the length.

† Breadth measured after restoring the collapsed body-wall to a cylindrical form.

The ratio of body-length to the greatest breadth may be given at 1: .15—.25. As compared with 1: .3—.44 of *E. marshalli*, the present species must be said to have in general a distinctly more elongate shape.

Both MARSHALL and SCHULZE have stated that the body is more or less compressed laterally, presenting an oval form in cross-section. This is no doubt generally true. However, we

have here evidently a feature much subject to individual variation. Perhaps, as a general occurrence, the compression becomes gradually more and more marked as the sponge grows in size. Sometimes specimens of considerable dimensions may be approximately circular in circumference for nearly the entire length; such a case is found in Spec. *L* (of the above list), which, being preserved in alcohol and in good condition, has undoubtedly retained the natural form.

As a rule, the upper terminal region of the body may be said to have a roundish form in cross-section. Spec. *J* (Pl. VI, fig. 4) is exceptional in so far as the greater part of the body is nearly cylindrical, being almost circular in cross-section, while the upper end is perceptibly flattened, here the breadth measuring 30 mm. in one direction and 25 mm. in the other.

Constant seems to be the pronounced compression of the body-wall at the contracted inferior extremity, where the basal fibers are given off. To give the cases in which I have measured the diameters at this position:

Spec. *A* ..... 8 × 5 mm.
„ *B* .....10 × 7 „
„ *D* .....12 × 6 „
„ *I* .....17 × 11 „
„ *L* .....18 × 10 „
„ *Q* .....26 × 12 „

The compression at this end seems to be independent of that in the upper main portion of the body, for I have found the planes of the two not always exactly coinciding. They may be disposed even nearly vertically to each other; so, e. g., in Spec. *I*.

The compressed, inferior end is normally closed by a *bottom-plate*. The apparent absence of this in some specimens is probably due simply to damage after capture. It is of essentially the same appearance as that of *E. marshalli*. The same holds true of the strongly arched, often hemispherical *sieve-plate* of the superior end as well as the portion of the basal tuft nearest its point of origin. The occurrence of the bottom-plate and the condition of the basal tuft indicate that the mode of insertion of the species into the substratum is likewise the same as in *E. marshalli* (p. 93).

In many specimens the *basal tuft* is present as a clean, silky lock of considerable length. As more normal are to be considered the cases in which I have found the tuft form, a short distance below the point of its origin, a bulky, irregular or elongate mass, including a copious quantity of sand, shell-fragments, worms-tubes, &c.

Parietal ledges and the *cuff* have been hitherto considered to be entirely wanting in the present species. I must say that such is *not always* the case; in fact, both the structures mentioned seem to be of common occurrence, though they are never so prominently or so extensively developed as in *E. marshalli*. Here again it seems we have to do with a character which is subject to considerable variation according to individuals.

The beautifully preserved specimen I have shown in Pl. VI, fig. 4 (*J* of the list on p. 205) approaches most closely to the descriptions given by Marshall and Schulze in respect of the character of the external surface. In it, the parietal ledges are at most simply suggested, the interspaces between the parietal oscula having in general a gently convex, external surface.

Whereas, all other specimens before me (excepting one doubtful case with much abraded surfaces) show a greater or less number of ridge-like prominences or ledges, such as are fairly well exemplified in Pl. VI, figs. 1–3. Even the smallest specimen (*A*) exhibits a decidedly uneven surface, somewhat as in Pl. IV, fig. 9. The ledges in the larger specimens may be 5 mm. high but are more usually much lower. Their free edge may be said to be tolerably even; it is either blunt or sharp. In length the ledges are quite indefinite, often rather short. They run in the usual, irregular manner, but generally in either transverse or oblique directions.

In a certain specimen (Spec. *I*) I have found the ledges for the most part somewhat unusually sharp-edged and supplied along the edge with an inconspicuous, palisade-like row of spicules, projecting to a length of about half a millimeter. In the case of the more blunt-edged ledges of the same specimen this palisade was wanting. Nor have I noticed it on any ledges in all the rest of my specimens. On close observation it was seen to consist of spicules similar to those which were likewise inconstantly found on the sharper-edged lappets of *E. marshalli* (p. 97).

The *cuff* is on the whole inconspicuous, especially so in the smaller specimens. It is quite usual that different parts of the sieve-plate circumference show the cuff in different states of development. It may in places even be wholly wanting. In its highest development, the breadth does not exceed 4 mm., as measured on the upper surface. It is of moderate thickness and sharp-edged, being directed either outwards or more or less upwards. Generally there exists no spicular fringe along the edge;

sometimes, however, spicules of quite inconspicuous length may project out here and there. The line of insertion of the cuff, i. e., the juncture-line of the lateral parietes with the sieve-plate, as seen from the side, is generally irregularly wavy.

The parietal oscula measure 2 mm. or less in diameter. They are arranged on the whole with tolerable regularity in longitudinal and transverse rows (Pl. VI, figs. 1, 4). Here and there, this regularity is subject to disturbances, conditioned in a measure by the development of, and the course taken by, the parietal ledges. Thus, by the sides of an obliquely running ledge it is usual to find the oscula arranged in rows running parallel to it. In some specimens (e. g., Spec. *Q*, shown in figs. 2 & 3), the distribution of the oscula may be said to be generally rather irregular, which fact may stand in relation to the wide-spread occurrence of ridge-like elevations over nearly all of the external surface.

With regard to the appearance of the parietes on the internal side and to the arrangement of beams in the skeletal framework, what I have recounted for *E. marshalli* may be said to be essentially applicable to the present species also.

Marshall ('75) had described the occurrence of both the circular and the longitudinal skeletal beams in sets of twos running side by side—such as might arise by the splitting lengthwise of every, originally single beam—as somewhat constant and characteristic of the species, which generalization has however not been fully borne out by facts subsequently brought to light. F. E. Schulze ('87, p. 79; '95, p. 30) has found in the small specimen examined by him (Spec. *C* of the list on p. 205) that

the peculiarity referred to in the arrangement of the beams occurred only here and there without regularity in the longitudinal system, and as regards the circular beams, only in the upper region of the body. My observations are in general accord with SCHULZE's. The arrangement of the longitudinal beams is exactly similar to that observed by SCHULZE ('95, p. 25) in *E. simplex* and by me in *E. marshalli* (p. 94). The same may also be said with respect to the circular system. Only I have to add that the relatively close arrangement of the circular beams noticed by SCHULZE in the upper region of the body is to be observed only in the younger specimens in which that region is still actively growing, and the said beams are there either undergoing, or have comparatively recently undergone, multiplication by splitting. In a specimen of 138 mm. length (Spec. *D*), I have found the region near the upper end still characterized in the way indicated. In all the larger specimens, the circular beams are set well apart from one another, notwithstanding the occasional occurrence of anastomosis. After the specimen has nearly attained full size, a number of the uppermost circular beams seem to deviate from their regularly transverse course and become more oblique and wavy, so that they often anastomose and even intersect one another. At their juncture with the sieve-plate, they are frequently seen to be prolonged, like the longitudinal beams, into the beams of that plate, similarly as described by me for *E. marshalli* (p. 94).

The number of skeletal beams has been counted in five specimens, as follows :

Spec.	Number of circular beams.	Number of longit. beams at the upper end.	Number of longit. beams at the middle.	Number of longit. beams at the lower end.
A	49	36	25	18
D	54	35	32	23
E	45	?	31	25
L	50—56	35	35	29
Q	65	?	44	28

I claim no more than approximate correctness for the figures in the above table. In specimens *E* and *Q*, instead of the number of longitudinal beams at the upper end, I have counted that of the sieve-plate beams arising therefrom; these were found to number 38 and 49 respectively.

The majority of the meshes of the skeletal framework are perforate, that is to say, they each inclose a parietal osculum. The so-called interstitial or imperforate meshes occur, several in succession one behind the other, between any two, relatively closely situated, longitudinal beams; they also occur isolatedly, without any regularity as to their distribution.

The spicules are always and everywhere free. I find this to be the case even in the largest specimen (*Q*) before me.

Spiculation.

Under this head, my studies go essentially to confirm our previous knowledge as derived especially from F. E. Schulze's works ('87, '95). Moreover, there exists no marked difference between the spiculation of this species and that of *E. marshalli* or *E. imperialis*. I may therefore be brief in my account.

The large *oxystauractin-principalia* of the circular and the longitudinal skeletal beams may measure 4·5 mm. in length of the longitudinal axis and 90 μ in breadth of rays near the center. Other spicules of the beams are almost exclusively thetactins of the usual shape, rarely diactins and paratetractins. The thetactins and diactins are occasionally sufficiently large and strong to be classed with the principalia ; all the rest are thin, ranging from 7 to 20 μ in thickness near the center.

The parenchymalia of the loose tissues are again predominantly thetactins, quite variable in size, running partly in strands and partly in more or less diffuse arrangement. Occasionally there occur paratetractins, rarely stauractins and pentactins, especially among the larger parenchymalia. Many of the comitalia in the strands are thin and rather short diactins, provided with four tubercles at the center.

The *oscularia* (Pl. VI, fig. 10) are predominantly diactins, which have been very aptly called by MARSHALL compass-needle-like. Length 200–600 μ and over ; breadth near the middle 6–17 μ. The center usually with two or four oppositely placed tubercles. The oscularia are densely crowded, with their long axis disposed paratangentially to the edge of the oscular membrane. In the ring-like zone occupied by them, the innermost are generally the smallest. The outermost are the largest, and some of these may have one or more of the central tubercles produced into shorter or longer lateral rays, thus assuming the form of thetactins, tetractins or pentactins and even hexactins. These lead over the oscularia on the one hand into the parenchymalia, and on the other, into the gastralia.

The *basalia* (Pl. VI, fig. 9) differ in no way from the same of *E. marshalli*, except in being slightly more slender and in having perceptibly smaller anchor-heads. The anchor-teeth, of which there are 3–7 in each head, are strong and about 40 μ long. The distance from tip to tip of any two oppositely situated anchor-teeth measures 70-85 μ. The entire head is of about the same length. The shaft is less than 20 μ thick close to its origin from the head, only about 7 μ at a short distance above the axial cross, and not more than 30 μ in the thickest part farther above.—Some abnormally formed anchor-heads that I have found are figured in Pl. VI, figs. 7 & 8. In one of these cases the teeth are developed only on one side of the miter-shaped knob; the suppression of the development of teeth on the other side is evidently due to the head having lain with that side pressed against a compact bundle of its fellows.—I have discovered no more pentactin-anchors than SCHULZE did.

The *dermalia* may be nearly 1 mm. long. On the whole they are somewhat smaller than in *E. marshalli*. All the rays are nearly smooth throughout and tapering, but usually bluntly pointed at the free end. Distal hilt-rays mostly 90–130 μ in length and 3–7$^1/_2$ μ in breadth near the center. Paratangential rays 110–120 μ long.—Exceptionally and then only along the edge of especially sharp-edged ledges, the dermalia may be of unusually large size. The hilt-ray may here reach a length of 400 μ. It participates, together with slender diactins, in the formation of the inconspicuous row of bristles, before mentioned as having been found in a certain specimen.

The *gastralia* and *canalaria* are pentactins showing the rudi-

ment of a sixth, proximal ray in the form of a small protuberance. Paratangential rays 85–115 μ long and 3–7 μ thick near the center ; smooth nearly all over. Distal ray somewhat longer, sometimes considerably so ; in the larger gastralia it may be sparingly beset with small prickles near its distal end.

Of the hexasters, the *floricome* measures 75–88 μ in diameter.

The *oxyhexaster* (Pl. VI, figs. 5 & 6) is smaller than that of *E. marshalli*, measuring 50–60 μ, sometimes up to 70 μ, in diameter. It is present in abundance,—decidedly much more so than in either *E. imperialis* or *E. marshalli*. Compared with the same in either of these species, both the principals and the terminals are somewhat more slender. The principal is 7 μ long (as measured from the center of the axial cross) and $2^1/_2$ μ broad at the middle. It bears usually 3–4, rarely 2 or 5, divergent terminals at the outer end.

The *graphiocome* was recognized to be present in the species for the first time in '95 by F. E. SCHULZE, although its terminals—the rhaphides—were known long before. I find it is common. It may measure 245 μ in diameter, the rhaphides being 114 μ long, when fully developed. The latter, after they have fallen off from the principals, are still found as usual in the superficial region of the sponge-wall, though not in such great abundance as in *E. marshalli* nor in such regular arrangement as has been ascribed to their sheaves by MARSHALL.

The *sieve-plate* shows the parenchymalia (principalia and comitalia) mainly consisting of thetactins and diactins. The former seem to furnish the principalia more often than do the latter. Occasionally stauractins may occur among the parenchy-

malia. For the rest, the spiculation of the plate is essentially the same as in other species.

Miscellaneous Notes.

In Pl. VI, fig. 2, I call attention to the presence of a small, accessory sieve-plate on the side of the sponge, at some distance from the normal, terminal sieve-plate. A similar case of abnormality has also been noticed under *E. marshalli*.

Another observation, which I should mention in this connection, is that once in a specimen (*L*) of *E. oweni* the sieve-plate was found to have an unusually irregular outline, and seemed in certain places to have appropriated the adjoining parts of the lateral parietes by converting the skeletal beams, as these are usually arranged, into sieve-plate beams.

The above cases of abnormal development are, I think, of interest, as demonstrating the fundamental unity of the sieve-plate with its angular meshes and the lateral wall with its round, parietal oscula.

The Crustacean inmate of *E. oweni* is *Spongicola venusta* DeHaan, the same as in *E. marshalli* (see p. 201). The type of that Crustacea, described by DeHaan in the Fauna Japonica, was probably taken from the specimens of *E. oweni*, which were taken to Europe by Major v. Siebold. Of all the specimens of *E. oweni* I have examined, seven possessed each a pair—invariably a male and a female—of the Crustacea. The others contained some one, some none at all; but since the sponge-wall was more or less damaged in all of these cases, loss of the inmate may possibly have taken place in certain instances.

The comparative facility with which specimens of *E. oweni* could be got by purchase or otherwise in Fukuoka, Shimonoseki, &c., is undoubtedly due in a great measure to the fact that they are in some demand among the folks in those parts of the country, on account of an old custom connected with their marriage ceremony. The custom consists in including a Euplectella among the articles with which the room of the ceremony is decorated, or which are taken by the bride to the bride-groom's house. It is held to be a felicitous object betokening eternal connubial love on account of the presence of the inmates in an inseparable pair. In the long list of gifts, which the present Emperor and the Empress of Japan received from their subjects on the occasion of their 25th wedding anniversary, are mentioned several Euplectellæ, gifts humble in themselves but full of well-wishing sentiments. The Japanese name for Euplectella, Kai-rō-dō-ketsu (written 偕老同穴), means, as was correctly pointed out long ago by MARSHALL ('75), something like 'Together unto old age and unto the same grave.' Perhaps the name may have seemed to the Japanese mind all the more appropriate, since, by simply changing the first of the four ideographs into one which means 'the sea' (海) and yet without changing at all the pronunciation of the entire combination, the name may be made to signify 'Lobsters in the same cell.' In fact the name is often written in that way; thus, 海老同穴.

EUPLECTELLA CURVISTELLATA NOV. SP.

Euplectella, TAKESHITA 19'.

In the July number, 1900, of the Zoological Magazine (published by the Tōkyō Zoological Society) appears a brief notice by Mr. TAKESHITA, of the Kagoshima Middle School, of the discovery of *Euplectella* sp. off the southern coast of the Province of Satsma in Kyūshū. A specimen was obtained from a fisherman in that district, where, it is said, Euplectellæ are often brought up from a depth of 70–100 *hiro* (say, 100–142 m.) by the hooks of long-lines, sometimes to the number of three or four at a single haul.

At my request, the specimen was kindly sent to me for examination, just in time to insert its description in this work. It was in a badly dilapidated condition but nearly entire, the parts being sufficiently preserved to give a fairly good idea of its original appearance. It may at once be stated that it most closely resembles *E. oweni*, but differs from that species in its peculiarly characterized oxyhexasters, which seem to sufficiently justify its erection into a new and distinct species. I propose to call it *E. curvistellata*. However, with more materials at hand, it may possibly turn out advisable to regard it as only a variety of *E. oweni*.

The body is 165 mm. long. On restoring it from a collapsed state to a tubular form it is found to be only perceptibly bent and to be slightly ventricose in the lower half. The greatest breadth measures 37 mm., against 30 mm. in the region of the cuff. The manner of juncture of the body with the sausage-shaped

mass of the basal tuft is exactly the same as in *E. marshalli.* The bulky basal mass, 115 mm. long, includes sand, pebbles and fragments of shells, etc., among its fibers, indicating the character of the sea-bottom.

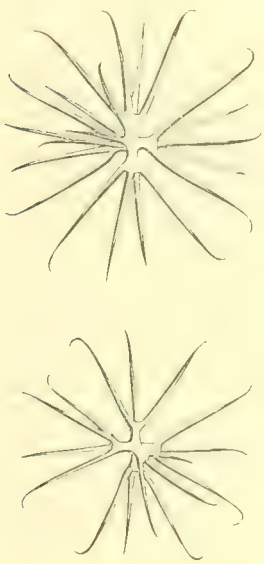
The external surface, though much damaged, may safely be said to be tolerably even. Parietal ledges, if at all recognizably developed, must have been rather insignificant and of only occasional occurrence. A small portion of the cuff, $2^1/_2$ mm. in width, remained to the specimen. In all these respects and in the appearance of the sieve-plate, the resemblance to *E. oweni* must be said to be very close indeed. The same is true of the essential points in the spiculation.

Of the *skeletal framework* I have counted 40 circular and 36 longitudinal beams. The principalia to both these beams are large oxystauractins. In the sieve-plate beams, they are mostly represented by oxydiactins. Let it also be expressly mentioned that the *oscularia* are mainly compass-needle-like diactins as in *E. oweni.* The *basal anchoring spicules* likewise exactly as in that species. The *dermalia* of the usual shape have the distal hilt-ray 60–160 μ long and 6–$9^1/_2$ μ broad near the spicular center.

The *floricomes* measure 91 μ in average diameter. *Graphiocomes* in intact condition have not been found ; but their presence is not to be doubted, since the rhaphidial terminals occur here and there near the external surface in the usual disposition, though not in great numbers.

Now what constitutes the characteristic feature of this species is the somewhat unique appearance presented by the *oxyhexasters.* These are very abundant everywhere in the wall. Compared with those of *E. oweni*, they are decidedly larger,

measuring 75–100 μ—on an average 90 μ—in diameter (against 50–70 μ of *E. oweni*). The rays, both principal and terminal, are somewhat stouter. (Compare the annexed woodcuts with Pl. VI, figs. 5 & 6). Moreover, the smooth and finely attenuated terminals, of which there are 3 or 4 (sometimes 5) to each short principal, are near their free ends always more or less distinctly curved, frequently in an almost hook-like manner. For the rest of their length, the terminals are nearly straight. The bending takes place apparently without any definite rule as to its direction. The terminals belonging to the same principal are sometimes bent all alike outwards, i. e., away from the axis of the principal. At other times they may be bent some outwards and some inwards, or in any intermediate direction.



Two oxyhexasters from E. curvistellata. Magnified 440 ×.

Finally, let it be mentioned that the specimen contained in its gastral cavity a pair of *Spongicola venusta*, known also to inhabit *E. aspergillum*, *E. marshalli* and *E. oweni*. Besides, I have a specimen of *Hyalonema sieboldi* harboring a pair of the same Crustacea. The identity of the inmate may be taken as suggestive of similar bathymetrical and other conditions under which the above-mentioned Hexactinellid species live.

Regadrella O. Schm.

The genus *Regadrella* had long been known in a single species, *R. phœnix*, which was first described by O. Schmidt ('80). In '96 I referred to that genus a species which I briefly described under the name of *R. okinoseana*. Recently F. E. Schulze (19') has described his *R. decora*, respecting which I greatly doubt if it can be held to be distinct from my *R. okinoseana*. In the present Contribution will be added another new species to be called *R. komeyamai*, which shows an indubitably close affinity to *R. phœnix* O. Schm. Perhaps we have still another species in the specimen which will also be described later on, provisionally identified as *R. phœnix*.

Practically, three species come into question in determining the generic status of *Regadrella*; *viz.*, *R. phœnix*, *komeyamai*, and *okinoseana*.

Granting that all these were correctly referred to one and the same genus, the generic diagnosis will have to be drawn up somewhat as follows:

Tubular or saccular Euplectellid, firmly attached to the solid substratum by a hard, knobby base. Superior end having a sieve-plate, which may be represented by remnants of its beams—a number of spicular rays in a wreath. Lateral wall with round parietal oscula. Skeletal beams running obliquely; with strong diactins as their principalia; fused together in the lower part of the body. Parenchymalia accessoria thin-rayed diactins, hexactins, &c. Hexasters of 3 kinds: 1) floricome, 2) graphiocome and 3) either onychaster or oxyhexaster, which latter is generally reduced to the form of oxystauraster.

To give the differential character of each species in the form of a key:

a.—Parietal ledge only indicated. With onychaster (no oxyhexaster or oxystauraster). Large oxypentactin parenchymalia present along the superior rim of the lateral wall. Prickly parenchymal oxyhexactins not present.

*a*¹. With true sieve-plate. Cuff rudimentary. Without pro-tal needles in tufts on the lateral wall ..... *R. phœnix* O. Schm.

*b*¹. Sieve-plate represented by a spicular wreath (corona) guarding the superior terminal osculum. Cuff well developed. With long prostal needles in tufts on the lateral wall..... *R. komeyamai* Ij.

b.—Parietal ledge conspicuously developed. Without large oxypentactin parenchymalia along the superior rim of the lateral wall. With oxyhexaster, predominantly in the form of oxystauraster. Numerous small prickly oxyhexactins present in the parenchymalia. (True sieve-plate present, surrounded by a well developed cuff. Without tufts of prostal needles) ..... *R. okinoscana* Ij.

The idea of removing *R. okinoscana* altogether from the genus has often suggested itself to my mind. In fact I think this step might be taken with some practical advantage to the systematic. The presence of oxyhexasters and oxystaurasters instead of onychasters, and also of small, prickly or spinose, parenchymal oxyhexactins in large numbers, keep this species somewhat apart from the other two, which *inter se* show an essential agreement in spiculation. Another not unimportant distinction from those species seems to lie in the fact that in it the large oxypentactin parenchymalia, which in *R. phœnix* give a strong support to the sieve-plate and in *R. komeyamai* supply the coronal rays, are wanting. Perhaps it may not be altogether inappropriate to associate *R. okinoscana* generically with *Corbitella speciosa* (=*Habrodictyum speciosum* Quoy & Gaimard), which, to judge from W. Thomson's ('68) statements, seems to agree in a measure with that species, amongst other points in being in possession of oxyhexasters and evidently also of small smooth-rayed hexactins which may correspond to the spinose parenchymal oxyhexactin of *R. okinoscana*. However, in view of uncertain-

ties in our knowledge of *Corbitella*, *R. okinoseana* may after all for the present best be left as it is.

Regadrella is evidently much more nearly related to *Tœgeria* F. E. Sch. than may appear at first sight. The coronal wreath of *T. pulchra*, the only known species of that genus, is to be considered as of only specific rather than generic value, as will be enunciated anon under *R. komeyamai* which possesses the same structure. The spiculation in the two genera is to a far-reaching extent, essentially similar. The small, spinose, parenchymal oxyhexactin of *R. okinoseana* is represented in *T. pulchra* Chall.-Rep., pl. XI, fig. 2). All the three kinds of hexasters seen in both *R. phœnix* and *R. komeyamai* are here likewise present. Floricomes and graphiocomes were mentioned as such by F. E. Schulze (*l. c.*, p. 95) in *T. pulchra*; for onychasters I take the hexaster-form which that writer has specially described as having 4–6 *small hooks projecting transversely* at the extremity of rather slender terminals. Now, what constitutes the most characteristic feature of *T. pulchra* is the presence, in addition to above-mentioned hexaster-forms, of well-developed discohexasters, whose arched terminal disc bears six *strong* hooks. The spicule called by F. E. Schulze the 'discohexact' (*l. c.*, pl. XI, fig. 3) is, in my opinion, to be classed under the above discohexaster simply as a case of hexactinose discohexaster.* Since now such a discohexaster differs from an onychaster merely in the more strongly developed state of the terminal disc or whorl of teeth, the distinction of *Tœgeria* from *Regadrella* may be said to rest on nothing more than the relative degree of the development of parts in certain discohexasters.

* The hexactinose discohexaster apparently occurs also in *Eudictyum elegans* described by Marshall ('75). With a better knowledge, than we at present have of this species, it may possibly be found necessary to regard *Tœgeria* F. E. Sch. as only a synonym of *Eudictyum* Marsh.

REGADRELLA OKINOSEANA Ij.

Pls. VII and VIII.

R. okinoseana, Ijima '96, p. 250.

R. decora, F. E. Schulze 19', pp. 30–34, 43; pl. VI, figs. 10–18.

From time to time several specimens of this exquisite species have been obtained by Kuma in the Sagami Sea, though mostly in fragments. The exact localities are as follows:

Gokeba, about 572 m. (400 *hiro*=313 fms.).

Okinosé, about 358 m. (250 *hiro*=196 fms.).

Outside Okinosé, over 500 m. (350 *hiro*=274 fms.).

Inside Okinosé by Ena-line, between 429 and 572 m. (3–400 *hiro*=235–313 fms.).

Iké-line* by Mochiyama-line, about 832 m. (580 *hiro*=454 fms.).

Many of the specimens bear at the base a sample of the bottom, invariably a tufaceous rock, to which they are firmly attached.

If I am right in regarding *R. decora* F. E. Sch. as identical with *R. okinoseana*, a very wide distribution is to be ascribed to the species. Schulze's type of *R. decora* came from a spot in the Indian Ocean, SW. of Cape Comorin and 787 m. deep.

Attached to the skeletal stumps of dead specimens from Okinosé Inside, I have found an interesting series of the young,

* This line, not given in Pl. XIV, lies a short distance to the east of the Jōgashima Lt.-house line.

which will be described after I shall have finished with my accounts of the full-grown specimens.

General Characters of Full-Grown Specimens.

The species may attain a very considerable size. A superb specimen was that which was purchased by Prof. A. Agassiz in Yokohama and taken to the United States. The vase-like body measured 400 mm. in height. Diameter of the sieve-plate 140 mm. Width of the cuff 60 mm. in the broadest part. Some of the parietal ledges as high as 55 mm.

Another large specimen, belonging to Mr. Alan Owston, measured 420 mm. in total height. The upper portion of the body was rather abnormally inflated into a bulbous shape, presenting diameters of 270–330 mm. Near the basal end the breadth measured 30–33 mm.

In the Sci. Coll. Museum there is one exquisite specimen which is not very large but is preserved in alcohol in an almost perfect condition. This is shown in Pl. VII, fig. 1, in half natural size, and will here be described somewhat in detail.

It is of an elongate vase-like shape, 185 mm. high, and of very irregularly corrugated external aspect on account of the parietal ledges. The breadth measures 72–80 mm. across the cuffed upper end ; 40–58 mm. directly behind the cuff ; 65–75 mm. at the middle of the body ; and 15–20 mm. at the contracted base close to the solid, irregularly lobed basal mass. The cross-sections of the body-wall near the upper and the lower ends are nearly oval ; it is more irregularly shaped in the middle.

The *sieve-plate* is well arched and oval in outline, measuring

37 mm. by 54 mm. in diameter. In general appearance it agrees well with *Euplectella marshalli*. The beams are mostly $^1/_4$–1 mm. wide, the thinner ones being somewhat laterally compressed but the thicker ones so flattened as to present broader sides externally and internally. In two or three places they join together to form nodal plates 2–4 mm. in width. Among the beams no radial spoke-like arrangement can be discerned. This is in accordance with the absence, in the sieve-plate border, of such large oxypentactins as are present in other species of the genus, which might give rise to a radial arrangement of the beams.

The meshes are oval, oblong or angular but always with rounded corners. They measure more usually 1–4$^1/_2$ mm. across. An interesting fact is that most of the meshes are each provided, like the parietal oscula, with a thin, narrow, iris-like membrane that leaves a round aperture in the middle.

The *cuff* is very broad with a wavy edge-line, measuring in places 22 mm. in width, and is irregularly undulating, being directed obliquely upwards and outwards. It is soft and moderately thick. The free edge bears an inconspicuous row of projecting spicules, not more than half a millimeter in length.

The *ledges* are low in a narrow zone directly behind the cuff; so also in the basal section of the sponge. In the remaining major part of the wall, they are very prominently developed in the form of thick, round-edged and extremely irregular ridges, which vary greatly in height at different points. They may in places be 20 mm. high and 4 mm. or more thick. They frequently branch in their course, making it difficult to determine the general direction they take. Here and there are seen evident

signs of the ledges having fused together secondarily, occasionally leaving an arch-like or tunnel-like passage underneath. Sometimes the elevation surrounds a depression containing a solitary parietal osculum and at other times incloses an irregular valley-like space in which several oscula may lie side by side. Like the cuff, the ledges are soft and can be easily torn away from the sponge-wall, except in the basal region of the body where they are firm owing to the extensive amalgamation of the megascleric elements.

The *parietal oscula* are round, up to 3 mm. in diameter, and are surrounded by a narrow oscular membrane as in *Euplectella*. Their distribution must be said to be irregular, being situated 3–8 mm. and sometimes even 15 mm. distant from one another.

The surface of the parietal ledges presents for the most part a rather close-grained texture. However, towards the base of the ledges and over the depressed area around the parietal oscula, there are visible, by the aid of a hand-lens, the usual dermal latticework of a most delicate nature, extending itself close to the oscular edge. Beneath this layer are discernible the variously sized apertures of incurrent canals, measuring up to about 1 mm. across. The same apertures are also exhibited by both the superior and the inferior surfaces of the cuff.

Leaving the ledges out of consideration, the sponge-wall must in general be said to be thin, except at the much thickened, blindly closed end at the extreme base. In most places the wall does not exceed $2^1/_2$ mm. in thickness. Nevertheless, the entire

specimen is sufficiently rigid to keep its shape when taken out of the spirit in which it is preserved.

To illustrate the appearance of the parietes on the inner side, may serve Pl. VII, fig. 2. It is taken from a specimen wanting the upper end but otherwise well preserved and which has been longitudinally bisected for this special purpose. The two kinds of openings visible on this side present much the same appearance as in *Euplectella*. The openings of the excurrent canals usually measure less than $1^1/_2$ mm., but occasionally 2 mm. across. Unlike in *Euplectella*, the narrow ridges produced by the main skeletal beams are all more or less obliquely disposed and intersect one another at various angles. However, it can be distinctly observed in this as well as in other specimens that certain beams or spicular bundles, lying innermost in the wall and evidently corresponding to the circular beams of *Euplectella*, are relatively more transversely disposed than others situated nearer the exterior.

As could be observed in the complete specimen before described, the skeletal beams of the parietal wall, at the upper end, pass directly into those of the sieve-plate. If, therefore, the cuff and all other loose parts be made to fall off the megascleric beams, the framework of the lateral wall should be seen to continue itself without any demarcation into the sieve-plate, much in the same manner, I should think, as in that old specimen well-known as the type of *Corbitella speciosa* (Q. & G.).

The lower end of the sponge-body shows the larger parenchymal spicules and their bundles firmly ankylosed by synapticular fusion, which may extend above for about one half or more of

the entire body-length. So that, after death and the washing away of all the loose spicules, only the inferior portion of the sponge remains with any degree of persistence as a perforated but compact cup with a solid knobby base. In this condition are several specimens now before me. Fortunately, all these, dead stumps as some of them are, still contain the spicules characteristic of the species, which puts the identification beyond the reach of doubt.

Pl. VII, fig. 4 represents, in natural size, the macerated remnant of the skeleton of a comparatively small and young specimen. It consists for the most part of fused spicules. I may remark that the general appearance of this specimen strongly reminds me of one of the two specimens on which O. SCHMIDT ('80, p. 46 ; Taf. VII, 3 A) based his *Rhabdodictyum delicatum*.

Pl. VII, fig. 3 shows in a typical way the dead skeleton of a large specimen. The wall exhibits externally an irregular network of hard and more or less prominent ridges. It scarcely needs to be mentioned that these arose by the soldering together of parenchymal bundles in the parietal ledges. In the depressed spaces bounded by the ridges are situated single, less frequently several, roundish gaps, indicating the position of parietal oscula in the living state. Immediately around the gap, the wall forms a netted plate made up of a number of spicular strands branching off from neighboring coarser bundles and running tangentially in all directions. The coarser bundles, some of which may be nearly 1 mm. thick, are seen to run in the main in two oppositely directed, oblique sets. In their course they freely split, unite and intersect or pass through one another, thus giving rise to an irregular basket-work which may, on that account, be readily distinguished from the more regularly framed skeleton of *Eu-*

plectella. On the gastral surface there are seen the bundles already referred to, the course of which more closely approaches the transverse than that of any of those visible on the external side.—Superiorly, the fusion of spicules gradually diminishes in degree and extent; the interweaving of the fused bundles becomes looser; finally, each of these runs out into fretted, tuft-like strands. At the same time the hard external ridges disappear, becoming replaced in the living state by the loosely supported ledges, which are of course lost after maceration.

Spiculation.

The two specimens shown in Pl. VII, figs. 1 & 2 (Sc. Coll. Mus. Nos. 487 & 488), were principally made use of in my study of the spiculation in full-grown individuals.

The *principalia* in the parenchymal bundles are large oxydiactins, which may attain a length of 35 mm. or more and a breadth of 220 μ in the thickest portion. They are nearly straight or gently bent, without an elbow-like bending at the middle. Towards both extremities they attenuate to thin, smooth or rough-surfaced, pointed ends.—The *comitalia*, accompanying the above principalia in a copious quantity, are mainly slender diactins,—not thetactins as in *Euplectella*. They are usually 10–16 μ thick; generally smooth but occasionally annulated or tubercled at the spicular center; subterminally rough-surfaced, the very end being smooth and rounded or conically pointed in the usual way. Just the same diactins as the comitalia occur in all parts of the wall either in loose arrangement or in strands by themselves.

Among the parenchymalia there also occur not infrequently smooth *oxyhexactins* of comparatively large or medium size. The rays are subterminally rough-surfaced; up to about 17 μ in thickness near the base; varying in length not only in different spicules but frequently also in the same spicule. Such a parenchymal oxyhexactin frequently occurs in the choanosome without apparent definiteness as to the orientation of its rays in relation to other skeletal parts. Sometimes however, there have been found some whose size, shape and situation, suggest that they are reserves, as it were, of certain dermalia. They seemed to require only to be pushed out more or less, in order to be classed with the dermalia. On the other hand, there are occasionally found similar oxyhexactins participating with one of the axes in the formation of a parenchymal strand. The said axis may then be greatly prolonged in excess over the other two. I think I may say that the oxyhexactins represent an intermediary between the dermalia and the diactins which make up the main contingent of the parenchymalia.

Characteristic of the species is the abundant occurrence of a kind of intermedial parenchymal oxyhexactins, which, for the sake of reference, may be called the *microxyhexactins* (Pl. VIII, figs. 24–26, 32), This is exceedingly variable in size but on the whole it is small, usually measuring 175–300 μ, sometimes only 110 μ, in axial length. The rays are 4–8 μ, rarely as much as 20 μ, thick at base; straight; attenuating to a fine point. They are invariably characterized by having the entire surface beset with numerous, vertically out-standing, minute prickles. The prickles are more pronounced in some cases than in others and are decidedly spiny. The axial filament in each ray reaches

right up to the pointed end, placing it beyond the reach of doubt that we have here to do with a true hexactin. Spicules of similar or exactly the same appearance are known from *Tægeria* as well as from *Walteria*.

The microxyhexactins are present in all parts of the parenchyma. They seem to be more abundant in the inner than in the outer trabecular layer. They mostly occur loosely, sometimes tightly clasped in the bundles of parenchymal diactins. Further, I have seen them situated and arranged after the manner of canalaria in places in the excurrent canals.

In the deeper parts of the parietes I have occasionally met with isolated spicules, which somewhat differed from, but seemed to integrade with, the microxyhexactins. We here have to deal with rather small pentactins or hexactins or such hexactins as approach a pentactin by the reduction to a greater or less extent of one of the rays (Pl. VIII, figs, 27, 28, 33). The rays differ from those of microxyhexactins in being somewhat thicker and less tapering, in having rounded or bluntly pointed ends and in being sparingly supplied with prickles only near the end. The prickles, however, have sometimes been found to extend nearly all over the rays, though in a weak state of development. I am inclined to regard these spicules as representing parenchymal microxyhexactins in the way of differentiation towards gastralia or canalaria.

The hard basal mass consists of a rigid, close and irregularly meshed framework of siliceous beams, which bear on their surface sparingly and unevenly distributed microtubercles. The beams arise by extensive synapticular fusion of all the parenchymalia in this region, except the intermedial microxyhexactins, which, together with the hexasters, usually remain free in the

meshes. In addition to the same megascleric elements as are found in the upper part of the skeleton, there are contained in the basal mass a large quantity of peculiar hexactins, which occur nowhere else and which I have called the *basidictyonalia*. The hexactins in question are comparatively small in size but have thick, plump-looking rays, which are nearly smooth or show a few microtubercles near their rounded ends (Pl. VIII, fig. 34). The basidictyonalia are at first loose but soon become soldered to the general framework of the region. Pl. X, fig. 17, representing a small piece of the basal mass taken from *R. komeyamai*, may just as well pass for the same of the present species; in it some of the beam nodes are plainly the center of basidictyonal hexactins. The secondary deposit of siliceous matter over the surface and the synapticulæ irregularly proceeding from it often make the hexactins unrecognizable as such externally, but the characteristic triaxial central filaments remain in the beams.

The basidictyonalia seem to be of quite general occurrence among those Lyssacine Hexactinellids which are attached to hard foreign bodies directly by a part of the wall, and whose spicules undergo extensive ankylosis in the basal region. F. E. SCHULZE figured them from the firm stalk of *Crateromorpha meyeri* (Chall. Rep., pl. LXI, figs. 5 & 6). To them I refer also the rigid reticulum of spicules described by the same writer ('99, p. 64) from the buds of *Rhabdocalyptus mirabilis*, which fact I have already had occasion to mention on p. 186 (foot-note). And, I shall have to demonstrate their presence in a series of other forms in the course of these Contributions.

The framework of the basal mass is especially close meshed, on account of an excessively abundant development of synapticular formations, in the bounding surface which is in direct contact

with the solid substratum. Here the meshes are not wider than the beams themselves. The irregular cribellate plate thus formed was known to F. E. SCHULZE ('87, p. 38; pl. LXIV, fig. 3) from *Rhabdocalyptus mollis*, etc.

Spicules which might correspond to the *oscularia* of *Euplectella* were not noticed in any of the specimens, except in a rather small individual from Okinosé (Sc. Coll. Mus. No. 490). In this, the iris-like membrane of parietal oscula (Pl. VIII, fig. 37) was supplied with an abundance of small spinose hexactins, most of which differed from ordinary microxyhexactins in having somewhat thicker rays terminating in rounded ends, and also in frequently having one or more of the rays reduced in length. Thus, they were not uncommonly pentactins, and occasionally even diactins, in all of which the suppressed rays were represented by knobs or rudiments of variable length. The presence of transitional forms, however, clearly indicated their derivation from microxyhexactins by modification. They are evidently a sort of spicules which is of inconstant occurrence in the species.

The *dermalia* (Pl. VIII, figs. 14–18) are hexactins of variable size and strength. Many of them may be said to be sword-shaped with the proximal ray more than twice as long as the paratangential rays; while others, especially those of weak development, may have that ray of nearly equal length, or even somewhat shorter than these. The distal ray is always distinguishable by its comparative shortness, by its rounded or conical end, and by the relatively more numerous and more pronounced development of the microtubercles on its surface.

Frequently, but not always, the distal ray is slightly swollen near the end, presenting a club-like shape (fig. 18). All the other rays are tapering toward the pointed end and nearly smooth all over or subterminally obsoletely tubercled.—The distal ray is usually 80–150 μ long; sometimes as short as to measure only 50 μ in length. The paratangential rays are 175–275 mm. long. In the strength of the rays, as also in the manner of arrangement of the dermalia, there obtains a noteworthy difference in different parts of the sponge surface.

Slender-rayed are the dermalia in the depressed areas around the parietal oscula (figs. 17, 18). The rays measure about $6^1/_2$ μ in average breadth near the central node. The paratangentials are arranged so as to form a tolerably regular, quadrate meshed latticework, with meshes 150–300 μ in length of sides. Whereas, on the parietal ledges, there occur on the whole somewhat larger and much stouter dermalia (figs. 14–16, 29), though these are by no means of uniform strength. On an average, the rays are here about 12 μ thick near the spicular center. The larger dermalia seemed to increase in number as they approach the edge of the ledges, although even in this part there may occasionally be intermingled such as are as weakly developed as any in the entire dermal system. Moreover, the dermalia occur on the ledges irregularly crowded, so that a regularly meshed latticework is not brought into formation.

The greatest development is attained by the dermalia along the free edge of the cuff (Pl. VIII, fig. 13). They may not inappropriately be called the *prostalia marginalia*. The shape is sword-like. Total length up to $2^1/_2$ mm. The rays reach up to 45 μ in breadth near base; all of them taper towards the pointed end. The free distal ray may be 800 μ long; it is beset for the

greater part of its length with erectly out-standing microtubercles. The paratangentials are comparatively very short (up to 240 μ in length); they are rough-surfaced only near the end. The prolonged proximal ray is nearly smooth all over. An idea of the large size attained by the dermal hexactins on the cuff-edge, and of the variability in size of the dermalia in general, may be obtained by comparing fig. 13 with figs. 14–18, all of which figures are drawn on the same scale of magnification. Not that all the hexactins on the cuff-edge are uniformly large, but there are mixed with them smaller ones which connect them with the dermalia of the general surface. The distal rays, in forming the inconspicuous marginal row before mentioned, are accompanied by a number of rhaphides, not with diactin comitalia.

Noteworthy is the fact that along the cuff-edge as well as in certain parts of the ledges, the stronger-rayed dermal hexactins apparently take their origin among the parenchymalia and are subsequently added to the dermal layer from below.

The *gastralia* are pentactins of various sizes and of irregular appearance in so far as the paratangentials are often not straight, and are of unequal length in the same spicule. The rays are frequently only about 175 μ long, while at other times they are fully four times as long, with an average breadth of 17 μ. The unpaired distal ray may be shorter or longer than the average length of the paratangentials. The rudiment of a sixth ray is generally present in the form of a hemispherical knob. All the developed rays are subterminally faintly rough, the very ends being rounded or pointed.

The gastralia are found in irregularly scattered distribution.

The paratangentials lie in direct contact with the parenchymalia and often run in association with bundles of these. It may be worth while to note that not infrequently some parenchymal fibers or strands intersect the paratangentials on the inner side.

Rarely and exceptionally there occur stauractins or thetactins in the place of pentactin gastralia.

Pentactin *canalaria* have not been observed.

The *floricomes* (Pl. VIII, fig. 23) are of typical form, measuring 98–107 μ in diameter. The number of terminals in a perianth is usually 6, sometimes 7 or 8. The terminal disc bears rather strong teeth, as a rule 3 (seldom only 2) in number. The inner border of the disc, when seen in lateral view, is indicated by a rounded angular bending of the contour-line on that side.

The floricomes are very common in depressed and therefore protected positions of the external surface. In regions immediately around the parietal oscula, every distal ray of the dermalia may be said to bear a floricome on its tip. In exposed parts of the ledges they occur but rarely, whether in the position just mentioned or in the subdermal region.

Graphiocomes in an intact state are exceedingly rare. Of common occurrence is their central portion (Pl. VIII, fig. 36) after the loss of the rhaphides. Such a relic consists of six principals, about 3 μ thick and 15 μ long, each bearing at its end a small disc, the outer surface of which is beset with short basal remnants of the rhaphides.

The *rhaphides*, 180–200 μ long, occur very abundantly, either in sheaves or in a scattered state, in the ectosomal region. As

a rule their one end is outwardly directed, and often freely projects more or less beyond the external surface.

On several occasions complete graphiocomes have been observed with terminals measuring only 30 μ or 25 μ in length. These were undoubtedly in immature stages of their development. Pl. VII, fig. 9 represents one such developing graphiocome taken from a young specimen.

Although the floricome and the graphiocome must be said to belong *par excellence* to the external trabecular layer, yet certain observations seem to prove that both may sometimes arise in the inner trabecular layer as well. In the latter layer there have at times been found floricomes apparently young in appearance, and that too under circumstances which made me disinclined to assume that they came there by dislocation. As to the graphiocome, a small and young specimen of the species showed several developmental stages of that hexaster, by the side of the relics of old ones, inside the chamber-layer and close to the gastral surface.

True *oxyhexasters* (Pl. VIII, figs. 19, 20) occur only occasionally and may therefore be easily overlooked unless a special search be made for them. On the other hand, their derivative, the *oxystauraster* (Pl. VIII, figs. 21, 22, 35), is abundantly present in both the outer and the inner trabecular layer, perhaps somewhat more numerously in the former than in the latter. In both kinds of the oxyasters, the diameter usually measures 68–100 μ, exceptionally only about 50 μ. The smaller sizes refer as a rule to oxystaurasters, while the largest size is found especially among the oxyhexasters. The principals are of moderate length and relatively slender, being about 11 μ long as measured

from the central point of the axial cross and about $3^1/_2$ μ broad on an average. The slightly swollen end of the principals bears 3–5, rarely only 2 or more than 5, terminals in a diverging tuft. In the case of oxyhexasters, the number of terminals to each principal frequently runs up to 8, 10 or even more. The terminals are nearly thrice as long as the principal; they are smooth, tapering, generally not straight but bent in a somewhat wavy manner. When numerous terminals form a tuft, they do not arise in a regular circle, but one or more may occupy a more central position than the rest. The tuft may be so divergent that any two opposite standing, outermost terminals form an angle greater than 90°. F. E. SCHULZE has called attention to the fact that in the oxystauraster in the type of his *R. decora*, those terminals lying in the plane vertical to that of the four principals stood out from the axis much more divergently than any other terminal. Something like this has also been noticed by me in certain instances, but not with any such degree of constancy as justifies one in deducing a rule therefrom.

The oxystauraster is undoubtedly derived from the oxyhexaster by the suppression of one of the axes. I have once seen a form with five principals and as many tufts of terminals. At the time I thought it was a genuine oxypentaster, but when I afterwards wanted to confirm my impression that the absence of the sixth arm was not due to a mechanical breaking off, I unfortunately failed to rediscover the rosette. In the few cases of oxystaurasters, in which I have specially entered into the examination of the axial filaments, I have seen no trace whatever of a third axial filament.

Respecting the spiculation of the *sieve-plate*, I have to notice the following:

The main support of the beams is afforded by spicular bundles whose components are essentially the same as in the parenchymal strands of the lateral wall. The only point of difference seems to consist in the fact that many of the diactins in the sieve-plate beam are of unusual shortness. These may be called compass-needle-like, with or without knobs at the middle. In extreme cases they are so short as to be only 250 μ long, with a breadth of about 25 μ near the middle. Spinose microxyhexactins occur but rarely. Floricomes and oxyasters have not been found, but the sheaves of graphiocome-terminals are common.

The dermal hexactins, which occur very closely crowded on the external side of sieve-plate beams, deserve special mention (Pl. VIII, fig. 31). The rays are thick and short, measuring 80–160 μ in length and 15–27 μ in thickness at their base. All the six rays in the spicule are nearly equal in length and in general appearance. They are generally tapering, minutely tubercled on the outer part, and end either rounded or in a point.

On the inside of the beams occur similar spicules which are however mostly pentactins but occasionally stauractins, and which are undoubtedly to be regarded as gastralia. The unpaired ray of the pentactins dips into the parenchymal bundle. The said spicules are present at wide intervals, so that the parenchymal bundles are largely exposed to view on this side of the sieve-plate.

Young Specimens.

The Science College collection contains an interesting series

of young specimens which I refer to the present species, notwithstanding certain discrepancies between them and the adult forms in both macroscopical and microscopical respects. The series comprises different stages, from one in which the body is smaller than a grain of rice to such as have the characteristics of the adult nearly completely developed. The specimens will here be described in the order of their development, beginning with the youngest.

1. On two stumps of dead skeletons (Mus. Nos. 369 & 370), which I have identified as *R. okinoseana* from microscopical examination of their spicules and both of which were obtained from Inside Okinosé during January, 1895, were found several small and delicate Hexactinellids of a club-like or elongate ovoid shape. They were attached by a small basal expansion at the narrowed lower end to the beams, on both the inside and outside of the dead specimen. The smallest individual of the lot was only 4 mm. long with a breadth of about 2 mm.; the largest, 13 mm. by 6 mm. In Pl. VII, fig. 5 are shown three of the small specimens in question, magnified about $1^1/_2$ times. The rounded upper end always shows a simple, round or oval osculum which leads into a deep, tubular, gastral cavity. The dermal surface is smooth and nowhere interrupted by parietal gaps. Thus, in macroscopic respects, the specimens can scarcely be distinguished from those of either *Vitrollula* or *Leucopsacus*; and even after gaining a knowledge of their spiculation, I was at first far from recognizing them to be the young of *R. okinoseana*, the same in species as the dead sponge to which they were attached.

In the first place, the dermalia (Pl. VII, figs. 8, 10, 11) are

exclusively pentactins, not hexactins as in all mature Euplectellids. The paratangential cross measures 275–650 μ in axial length and is generally slightly arched in conformity with the curvature of the surface (Pl. VII, fig. 8). Its rays are tapering and terminate in pointed or conically obtuse ends. Besides the usual roughness of surface near the end, they show a number of obsolete tubercles throughout their entire length, except along their inner side where the tubercles are nearly or quite absent. Generally but not always, the center of the paratangential cross exhibits on the outer side a gentle swelling. The unpaired proximal ray is developed to a length that usually exceeds by twice or even thrice that of the paratangentials. Like these, it is obsoletely rough ; but the roughness gradually loses itself proximad towards the finely pointed end of the ray.—Seen on the dermal surface, the paratangential crosses are rather irregularly disposed to one another or show a tendency to arrange themselves into a quadrate-meshed latticework (Pl. VII, fig. 10). Sections of the wall show that the elongated proximal ray reaches with its inner end nearly or quite to the gastral surface (Pl. VII, fig. 11).

No special gastralia are present. Along the gastral surface as well as in the deep part of the wall, there occur fine parenchymal diactins, mostly arranged in obliquely running and intersecting strands. In some of the specimens was observed the spinose microxyhexactin in isolated occurrence, while in others this kind of intermedial spicule seemed to be as yet not at all developed.

Much more constant and common is the graphiocome. Detached sheaves of rhaphidial terminals, 170 μ and more in length, are to be seen in abundance in the periphery of the wall. The central relics of the graphiocome were also seen in

fair numbers. Intact graphiocomes with terminals that had not yet reached their full-length (Pl. VII, fig. 9) were several times met with. No other hexaster-form has been found in these little specimens.

What systematic position to assign to the specimens was at first a great puzzle. The presence of pentactin dermalia seemed to make against their being regarded as Euplectellids, while the graphiocome pointed to their being at least a close ally of that family. Fortunately, however, I have found other young specimens which seem to represent transitional stages that lead over the simple spiculation of those little specimens into the more complicated system of the mature *R. okinoseana*.

2. From still another skeletal stump of *R. okinoseana* (Mus. No. 490, from Inside Okinosé, March 1898) was taken a young specimen of an elongate ovoid shape, 15 mm. long and 7–9 mm. broad. It is therefore considerably larger than the largest in the last described lot. A simple osculum, $2^1/_2$ mm. in diameter, is situated in the upper end. The dermal surface is no longer smooth but uneven. This is caused by the presence of small depressions, several of which have broken through the wall, while many others still remain closed. There can be no doubt that we have here to deal with the first formation of parietal oscula; the mode of their origin is essentially the same as in *Euplectella* (p. 105).

Examination of the spiculation also showed points of decided advance from the state noted in the last lot of specimens. The pentactin-dermalia present exactly the same characteristic features as in the latter. Only, mixed amongst them are occasionally found sword-shaped hexactin-dermalia, the distal hilt-

ray of which is rough-surfaced and rounded at the end. The diactin-parenchymalia and spinose microxyhexactins are present in greater abundance than before. Besides graphiocomes, there are now to be seen floricomes, oxyhexasters and oxystaurasters, though as yet in quite limited numbers.

In short the small specimen in question may be said to bear the essential characteristics of the adult *R. okinoseana*, except in the important respects that the terminal osculum is simple instead of being covered by a sieve-plate, and that the dermalia are predominantly pentactins.

3. By the side of the above specimen and on the same dead skeleton, was found another young specimen, which, though broken off in the upper part, must have had a somewhat larger body. A few parietal oscula open in the portion of the sponge-wall still remaining. As to the spiculation, the one important point in which this differs from the last specimen consists in the fact that the hexactin-dermalia are present in a notably increased number,—in about the same numerical proportion as the pentactin-dermalia (Pl. VII, fig. 12). The hexactin-dermalia compare well with those of old specimens of *R. okinoseana*. I have noticed that the pentactins have on an average stronger rays than the hexactins and that the latter are very variable in size, the smallest having very slender rays indicative of its comparatively recent origin. Further, I may say that the paratangentials of the pentactins generally, though not always, overlie those of the hexactins. The evidences are in favor of the conclusion that, whereas the first formed dermalia are pentactins, those which begin to develop later are all hexactins, and that these are, as a general rule, added to the dermal layer from below.

4. A still more advanced stage of growth is represented by the two specimens figured in natural size in Pl. VII, figs. 6 & 7 (Mus. No. 461, from Outside Okinosé, Dec. 15, 1898). One of these is of an irregularly tubercular shape and is 18 mm. high (fig. 6); it is attached to a piece of old basidictyonal mass, presumably of the same species. The other specimen (fig. 7) is a tubular sac broken off at the lower end. In both there is at the upper end a single, thin-edged and relatively large terminal osculum. In the uneven lateral wall, several small parietal oscula have opened, though many others are still represented merely by dimple-like depressions of the external surface. The immediate neighborhood of the terminal osculum is smooth-surfaced. The spiculation in both is essentially that of *R. okinoseana*; but one point requires special mention, viz., that, though the dermalia are predominantly hexactins, there are still to be seen the original pentactin-dermalia in some numbers.

In view of the fact that in the young of *E. marshalli* the delicate beams of the inceptional sieve-plate are exceedindgly liable to become lost by being broken off (p. 108), it might be questioned if a similar loss had not happened to the terminal osculum in the young specimens hitherto mentioned of *R. okinoseana*. Close inspection of the oscular edge in the two specimens just described, however, has seemed to show no sign of an unnatural severing off of any part of it.

5. A tubular specimen, contained in the same bottle as those referred to above under (2.) and (3.), has the lower end wanting but must have originally measured at most 50 mm. in total height, with a diameter of about 12 mm. in the middle of the body. The general character of the external surface much

resembles that of the young *E. marshalli* shown in Pl. IV, fig. 9; the ledges are indicated by low reticulate ridges with rounded edges, each depressed mesh containing a parietal osculum, of which there are many. At the upper end exists a transverse opening about 3 mm. wide. This is evidently the original single terminal osculum of the specimen. Directly adjoining it on one side, but not on the other, is a small ill-defined area in which the thin sponge-wall is perforated by several, somewhat closely situated, irregularly angular gaps of various sizes. I take this area to be a beginning of the sieve-plate formation. However, I entertain some doubt as to whether I have seen it in quite its natural condition, since the tissues at the parts bore signs of laceration to a certain degree.

Be that as it may, to my mind the first formation of the sieve-plate in Euplectellidæ probably takes place in the manner indicated. Thus, to the original single osculum at the upper end of the sponge, more oscula are afterwards gradually added in close proximity to it and to one another, converting the intervening part of the body-wall into the sieve-plate beams. The beams and nodes, after their establishment, may themselves also become perforated and thus may contribute to the multiplication of the sieve-plate meshes.

6. Finally I will mention a specimen 70 mm. high and 20 mm. broad at the widest part. It is attached to the basal expansion of the same dead skeleton on which the two young specimens mentioned under (2.) and (3.) were found. The body-form is peculiarly irregular, but this is undoubtedly due to accidental causes. The ledges are tolerably well developed. The upper end bears a definitely formed, but only slightly arched

sieve-plate of about 8 mm. diameter. The cuff is as yet narrow. Of the spiculation, I need mention only the fact that among the hexactin-dermalia are here and there intermingled the same pentactins, characterized by the peculiar distribution of microtubercles on the rays, as those which were found in the dermal layer of all the smaller specimens.

The pentactin-dermalia were not noticed by me in the adults. With advance in age, they are either lost or become so outnumbered by the multitude of hexactin-forms as to easily elude being seen.

From the data presented in the above, it may not be inappropriate to draw up the following summarizations.

Firstly as regards the macroscopic features :

R. okinoseana, in the first stage of postembryonal development, has a smooth and imperforate lateral wall, and is provided with a single terminal osculum. Soon (when the body measures, say, 13–15 mm. in length) the outer surface becomes uneven, and this stage is followed by the appearance of parietal oscula. Later (say, when over 20 mm. in length), the sieve-plate seems to become started by addition of new terminal oscula to the one already present. The initial number of the meshes must at all events be very few. Individuals, say, 50–70 mm. long, show the cuff and ledges indistinctly developed.

Secondly, with respect to spiculation :

The initial dermalia are pentactins.* To them, hexac-

*This remarkable fact is perhaps to be explained by assuming that at the time of the first appearance of the dermalia the superficial trabecular layer is of such limited thickness that it affords no space for the development of a sixth distal ray, the paratangentials being formed on its extreme outer surface. A phenomenon in a measure analogous to this is seen in the development of *Leucopsacus orthodocus*. In this species the first spicules formed in the

tins are soon added, at about a period when the parietal oscula have begun to break through. Henceforth the dermalia that newly arise seem to be all hexactins; so that these soon greatly outnumber the original pentactins. The earliest formed hexaster is the graphiocome, the rhaphidial sheaves derived from it being common at the stage when the dermalia consist as yet exclusively of pentactins. The formation of microxyhexactins, of the floricome, the oxyhexaster and the oxystauraster soon follows.

Soft Parts.

The *trabeculæ* (Pl. VIII, fig. 30) are abundantly developed in irregular cobweb-like arrangement. They are thin and filamentous, but here and there spread out into small film-like areas. The protoplasm is granular, moderately stained by borax-carmine. Nuclei belonging to it about $2^1/_2\,\mu$ in diameter, containing a group of chromatin grains.

Dermal membrane with meshes or pores of irregularly angular shape and of various sizes. Meshes separated from one another by thread-like, band-like or membrane-like trabeculæ. It is more or less extensively and continuously membranous towards, and on, the tent-like conuli produced by the distal rays of the dermalia.

Archæocytes generally about $3\,\mu$ in diameter; found forming

periphery of the larvæ are stauractins, which in the adults are replaced by pentactin-dermalia.—Probably the change in the dermalia, which I have endeavored to demonstrate in the young of *R. okinoseana*, is not peculiar to that species alone but is possibly common to a wide circle of forms belonging to the same family. I call attention to the stalked, evidently very young Hexactinellid figured by F. E. Schulze in the Chall. Rep., pl. xlii, figs. 5 & 6, and referred to by him as the 'undetermined Crateromorphid.' The essential agreement in spiculation between it and the little *R. okinoseana* I have described on p. 240 (*sub* 1.) makes me believe that it is more probably a young Euplectellid, the pentactin-dermalia of which assumably give place to hexactins in a later period of life.

in variable numbers small groups on the outer surface of chambers (Pl. VIII, fig. 29). Nuclei like those of the trabeculæ in both size and appearance; with definitely circumscribed cell-body consisting of granular protoplasm.

Thesocytes (Pl. VIII, fig. 30; *th.*) found in some numbers scattered on both the outer and inner trabeculæ; 7–15 μ in diameter. The contents consist of refringent, irregular granules or of variously sized spherules. In the same preparation, they are sometimes colored by borax-carmine and sometimes not. In the latter case, they present a yellowish-olive tint; amongst them the nucleus may be discerned as an indistinct red spot.

Chambers cup-like or thimble-like; diameter 45–75 μ (on an average 57 μ). Choanocyte-nuclei small (about $1^1/_2$ μ in dia.), pale, vesicular, without conspicuous chromatin grains in the interior; flattened, when seen in profile; generally 5–6 μ apart from one another. Beams of the reticular membrane thin, granular; meshes distinctly open (!).

Miscellaneous Notes.

F. E. Schulze (19', p. 33), when he was describing his *R. decora* from small fragmentary pieces, was aware of the fact that that species might possibly prove to be identical with my *R. okinoseana*, which was known to him from the preliminary description I have given in the Zoologischer Anzeiger in '96. If the two species are identical, as I consider them to be, the fault which induced Schulze to create a synonym must be said to have lain chiefly in the brevity of that description of mine.

Schulze was led to regard the two species as distinct, though very closely resembling each other, from a consideration of the

following three points in the spiculation of the type of *R. decora*: 1) The absence of oxyhexasters, which had been mentioned by me as present in the Japanese species; 2) the occurrence of large and strong oxydiactin parenchymalia principalia (15–20 mm. long, 100–200 μ thick), of which I had made no mention; and 3) the fact that the outer radial ray (120 μ long) of the dermalia was not particularly short, whereas I had called it short in my species.

As regards the first point, it is to be remarked that the oxyhexaster and the oxystauraster, as they occur together in *R. okinoseana*, are so closely similar, except of course in the point indicated by their names, that they scarcely deserve to be made into separate categories of much systematic significance. Moreover, the oxyhexaster occurs only occasionally and in numbers which, though subject to variation according to individuals, may be said in general to be insignificant in proportion to those of the other oxyasters. It may therefore under certain circumstances be easily overlooked; and besides, I think that in individual cases it may even be really entirely wanting, without, on that account alone, affecting the specific status.

The second and the third point will have lost their weight as distinctive specific characters from what I have given in this Contribution for the size of the spicules in question from *R. okinoseana*. One point concerning the dermalia seems to require a remark. These were described and figured by SCHULZE as tolerably uniform in size and in the strength of the rays. This is also the case in my specimens so far as those on the flat or depressed areas of the sponge-surface are concerned; it is on the ledges, especially toward their edges, that the dermalia are subject to a considerable variation in these respects. That SCHULZE

made no mention of this variability is probably due simply to the fact that the ledges were not represented in the pieces examined by him. After all I do not see in the organization of *R. decora* any tangible point by which it may be upheld as a valid species.

Malformations in parts of the body, brought about after the healing of injuries received by the sponge-wall, are as common as, and present appearances similar to those in *Euplectella*. Let mention be made here of a remarkable case of regeneration that came under my observation.

Of a medium-sized specimen there remained only a small lateral piece of the wall at its base, standing on the basal expansion; the rest of the body had been torn off and lost. The remnant shows the ledges and parietal oscula in a normal condition on the dermal side. On the gastral side, which had become directly exposed to the outer world, the loose sponge-tissues had greatly increased, thus adding much to the thickness of the wall. The thickening had become in one part all the more considerable on account of the formation of a large cavity right in the middle of the regenerated tissues. The cavity evidently served the part of a gastral cavity newly formed. On the one side it is bounded by the old sponge-wall with its parietal oscula; on the other, by a thinner wall consisting of the regenerated tissues, which are likewise perforated by a number of roundish gaps, the parietal oscula of the new formation. Some of these gaps are situated so close together as to form regular sieve-plate beams between them. The above case seemed noteworthy as illustrating the free formative plasticity dominant in the sponge-tissues.

Of the inmate in the gastral cavity, I can only report that the single specimen (Mus. No. 487) with a complete wall, now before me, contains an Ophiuron and a Polychæte Annelid,—no Crustacea.

REGADRELLA KOMEYAMAI NOV. SP.

Pl. IX and Pl. X, figs. 5–17.

During 1898, Mr. KOMEYAMA of Tōkyō presented to the Science College Museum a very beautiful and remarkably well preserved specimen of what proved to be a new species of *Regadrella*. I have named it in honor of the donor. The specimen was found by him at a collector's in Yokohama amongst other things that came from the Sagami Sea. I have no hesitation in assigning the locality of the specimen to that sea, though nothing whatever is known about the circumstances of its capture.

The specimen (Mus. No. 486; Pl. IX, fig. 1), which is in desiccated state, consists of two,—a large and a small individual, both thin-walled and lamp-chimney-like in shape. They stand close together being attached by means of large, irregularly lobed, basal expansions to a mass of soft, fine-grained tufa. More correctly, they have evidently not grown directly on the tufa, but on the basal mass of an individual of the same species long dead and destroyed.

GENERAL CHARACTERS.

The larger individual, which is the better preserved of the two, will here be first described in detail. It measures 225 mm. in total length. At the lower end the body is bent as if it had been directed upwards while growing with its base attached to a perpendicular surface. At the juncture with the knobby base, it measures not more than 30 mm. across. From that point superiorly

the diameter increases up to 75–87 mm. at about the middle. Thence upwards the body again gradually narrows to the region just behind the cuff, where the diameters measures 34–37 mm.

The superior end may be called truncate, not rounded. Cross-section of the body presents an irregularly circular outline. The wall is 2–5 mm., at places only 1 mm., thick.

The superior terminal osculum is 27–30 mm. in diameter. The entrance into it is guarded by a spicular wreath of *corona* as efficiently as by a sieve-plate.

The *corona* (Pl. IX, fig. 3) is composed of strong, straight or slightly curved, sharply pointed, spicular rays, which freely project out in a row from the angular oscular edge and stand out obliquely upward and inward to a length of 18 mm. or less. I count 39 coronal rays in all; at the roots the intervals between them are about $2^1/_2$ mm. on the average. To the naked eye the rays present a peculiarly glistening appearance, which is due to the rough shagreen-like nature of their surface. Looking at the corona from above, its inwardly directed rays are seen arranged like the spokes of a wheel, leaving in the center but a narrow, free passage between their points.

A coronal wreath of similar appearance has been known from *Tægeria pulchra* described by F. E. Schulze in the Challenger Report ('87). The same was later assumed by him ('95, p. 35) to have been mechanically produced by the accidental loss of the central part of a sieve-plate, such as is possessed by *Dictyaulus elegans*. Whatever be its nature in *T. pulchra*, the corona in *R. okinoseana* is a perfectly natural feature. There can be no doubt about this not only from the presence of it in the second specimen, but also from the facts: 1) that the rays are invaria-

bly quite free of other spicules which would have remained sticking to them, had a sieve-plate been mechanically torn off; and 2) that their shagreen-like surface—a feature which is also shown by all the prostalia on the cuff-margin as well as on the lateral surface—has apparently arisen in relation to the free exposure of the parts thus characterized.

At the same time there is no denying the fact that the corona had been ontogenetically derived from a sieve-plate. I assume that in an early developmental stage this comes into actual formation, if only to a partial extent, but that its component spicules are however soon loosened and lost as a normal process, leaving behind permanently only those that are deeply rooted in the lateral wall, viz., the coronal spicules. Genetically, therefore, the corona and the sieve-plate are to be considered as very nearly related structures, strikingly different though they appear to be. In this light the large terminal osculum should plainly and exactly correspond to the area which in certain other Hexactinellids is covered by a sieve-plate.

Since *R. komeyamai* and *R. phœnix* show a far-reaching similarity in other points of their organization, I am certainly not disposed to find in the corona of the former anything of more than specific value.

The *cuff* is tolerably well developed in a continuous ring (Pl. IX, fig. 3). Breadth up to 9 mm., as measured on the upper side. It is expanded outwardly and slightly inclined upwards. While its superior surface is comparatively flat and well marked off from the gastral surface by the angular oscular edge, the inferior surface slopes down to merge insensibly in the

general dermal surface. The cuff is therefore thick at its base and becomes thinner towards its free, outer edge.

From this edge there spring forth thin and inconspicuous prostal needles of various lengths, forming a palisade-like, but irregular and much interrupted row. The longest of them may project to a length of 6 mm. They have, as already mentioned, rough surfaces.

The *parietal oscula* (Pl. IX, figs. 1, 2, 4) are round, 2–3½ mm. in diameter; each bordered by a thin, iris-like membrane. They are tolerably uniformly distributed in right and left handed oblique rows. In the middle part of the sponge, they are situated at intervals of 6–18 mm. or more; near the ends, more closely together.

The *external surface* of the lateral wall may be said to be undulating on account of the low, flat and discontinuous swelling of the spaces between the parietal oscula. The swelling is by far too inconsiderable to be called a ledge, but culminates in irregularly conical or compressed elevations which are again small and never of any conspicuous height. Their summits, lying at intervals of 9–14 mm. from one another, bear each a group of thin, rough-surfaced *prostalia lateralia* before referred to. These project to a maximum length of about 10 mm., and are arranged, in groups of only a very few or at the most of several together, in either closely adherent or diverging tufts. Otherwise, as when they spring from along the edge of a compressed prominence, they form a short row.

The entire external surface is covered with a delicate, quadrate-meshed, *dermal latticework* formed of exceedingly fine beams (Pl. IX, fig. 4). The sides of the meshes measure not more than 0.4 mm. in length. Each nodal point of the lattice-

work is marked by a minute white spot, which under the microscope proves to be a floricome borne on the tip of the distal ray of each dermalia. The meshes are seen to be overspread with a cribellate dermal membrane.

Through the dermal latticework are distinctly visible the roundish or somewhat irregular-shaped apertures of the *incurrent canals*, which are of various sizes under 2 mm. diameter and are always rather shallow in conformity with the thinness of the sponge-wall. Between the said apertures the dermal latticework is in close contact with the parenchymal mass below.

Amongst the latter, the trend of the coarser and more peripherally situated *parenchymal bundles* is traceable from the outside with sufficient distinctness. Arising from the compact base of the sponge, they run irregularly upwards in oppositely oblique directions, branching and uniting and loosely interweaving with one another without regularity. In places the bundles are fully 1 mm. thick; more usually they are much thinner.

The *gastral surface* (Pl. IX, fig. 2) is devoid of a covering latticework. The parietal oscula are seen on this side to occupy each a more or less depressed position, their iris-like membrane lying on a level with the general external surface of the wall. For the rest the gastral surface shows an unevenness, firstly on account of numerous roundish excurrent apertures, and secondly, because of the most internally situated, coarse, parenchymal bundles which project in a ridge-like manner.

Close to a parietal osculum, the *excurrent canals* are but very small and shallow depressions. Farther away from it, they are much larger, often having a diameter of 2 or 3 mm. While some are pit-like though never very deep, others are flat de-

pressions into which two or more excurrent canals open in common.

The coarse *parenchymal bundles*, showing themselves on the gastral surface, pursue an irregular, but on the whole transversely directed course. Just inside the origin of the coronal rays along the superior oscular edge, there runs in a ring a strong, projecting bundle of fibers (see the upper part of fig. 2). Further, at this end of the wall a number of parenchymal bundles, running outside of the innermost, sinuously transverse bundles, assume a longitudinal disposition in association with the root of each coronal ray.

If, in an imaginary case, all the finer and loose spicules should be removed so as to leave the coarser parenchymal bundles alone *in situ*, there would remain a frail, wide-meshed and loosely interwoven basket-work, in which the outer and the inner bundles would be found, relatively speaking, to pursue directions inclined respectively in the longitudinal and the transverse directions. Thus, its general appearance would be much the same as in other species of the genus. However, one not unimportant peculiarity seems to consist in the fact that in the present species a much smaller portion of the skeleton at base, than in either *R. okinoscana* or *R. phœnix*, is subjected to synapticular amalgamations.

In the specimen described, the wall is quite firm in the region immediately adjoining the basal mass, which as usual is hard and compact. About 20 mm. above this region, the fusion of parenchymal spicules already becomes an occasional occurrence. A short distance farther above it is no longer to be found. I should think that, if all the loose spicules should be washed away, as they are after death on the native bottom, there would

remain with some degree of persistence only a basal cup of unsubstantial structure, in height probably not more than one-tenth of that of the original specimen.

With regard to the second, smaller individual, I may be brief. It stands out straight from the base without bending, the wall being more outbulged on one side than on the other. Total height 145 mm ; greatest breadth 63 mm. in one direction and 54 mm. in another. Breadth at inferior end 19–23 mm. Terminal osculum circular, 17 mm. in diameter. Cuff 2 mm. wide. Coronal rays not less than 33 in number, mostly 7–10 mm. long. Prominences on the dermal surface much less pronounced than in the larger individual.

Spiculation.

The *parenchymalia* consist predominantly of diactins, hexactins entering into their composition as occasional elements.

The *principalia* in the parenchymal bundles are oxydiactins which may attain a length of 30 mm. and more with a breadth of 130 μ at the middle. Their form and arrangement agree well with the corresponding spicule in the specimen which will next be described, identified as *R. phœnix* ; but they are relatively more slender.

The *accesoria*, occurring as comitals or running either loosely or in strands by themselves, are mostly thin and filamentous diactins with an average thickness of about 9 μ and a length of 10 mm. or more. The center is cruciately knobbed, more commonly only annulated. Subterminally usually slightly swollen

and sparsely microtubercled; extreme end rounded, sometimes conically pointed.

Parenchymal hexactins of small or medium size occur only sparingly in the bundles of the wall proper. It required a study on sections in order to verify this fact. They occur more commonly in the cuff as well as in the parietal prominences (Pl. X, fig. 11), in which parts they lie with one axis directed radially and in association with the proximal radial ray of the prostal hexactins soon to be described, into which they seem to merge by a gradational series of intermediate forms.—The parenchymal hexactins are generally under 1 mm. in axial length. Not infrequently the radially directed axis in those situated in the cuff or in the parietal prominences is much longer than the others. Thickness of rays about 10 μ or less; end generally bluntly pointed and sparsely prickled.

The *coronal spicule* (Pl. X, fig. 8) is evidently to be considered as a specially developed element of the parenchymalia. I may call it an oxypentactin with unequal rays, the sixth ray being represented by a mere boss. Its shape, position and manner of arrangement are essentially the same as in the corresponding spicule of *R. phœnix* (Pl. XI, figs. 5, 6). The same spicules in similar arrangement are also known from *Dictyaulus elegans* (Schulze '95).

With respect to its longest complete axis the coronal oxypentactin is disposed longitudinally. That axis is more or less curved, the concavity facing inwards. The atrophied sixth ray is situated on the concave side.

The superiorly directed ray of the longitudinal axis is the free coronal ray, the most strongly developed of all. In a large

specimen of the spicule that ray measured 18 mm. in length and fully half a millimeter in thickness at its base. It gradually tapers towards the finely pointed end. The surface is profusely equipped with strong, obliquely conical prickles (Pl. X, fig. 9) which cause the shagreen-like appearance when seen with the naked eye. Only small sections at the base and the end are smooth. As already noticed, the coronal ray springs out quite solitarily without the addition of other spicules, except occasional rhaphides which were found adhering to its surface.

The four remaining rays of the coronal oxypentactin are all smooth. The inferiorly directed ray is always much shorter than its opposite, coronal ray. Accompanied with comital diactins it forms the longitudinal parenchymal strands visible for a short distance just inside the oscular edge. Still shorter than the inferior ray are the paired lateral and the unpaired outer rays. The former together with compactly set diactins forms the ring-like ridge just inside the origin of the coronal rays. The unpaired ray extends outwards into the cuff which it transverses without protruding at the external edge. It thus affords a very efficient support to the cuff. Being situated just under the superior cuff surface, its course can be traced on that side as a whitish or a slightly raised streak proceeding radially from the origin of each coronal ray.

The *prostalia*, both marginal and lateral, are the radially directed, distal rays of very variously sized oxyhexactins, which may be called the *prostal hexactins* (Pl. X, fig. 11). These are, like the similarly situated stout dermalia in *R. okinoseana* (pp. 230, 235), linked to the parenchymal hexactins as well as to the ordinary dermalia by a gradational series of intermediate forms.

In a large specimen of prostal hexactins the distal (prostal) ray, which is always the longest and the strongest of all the six rays, may be 10 mm. or more in length. The opposite proximal ray is shorter, and shorter still are the four paratangential rays. While the proximal and the paratangential rays are entirely smooth, the prostal ray is, like the coronal ray, beset with short, conical, obliquely outwardly directed prongs (Pl. X, fig. 10). In many cases, however, it was found smooth on one side—generally the concave side of gently curved shafts. In the smaller prostal hexactins, the above prongs are more weakly and sparsely developed.

The *hexactin-dermalia* (Pl. X, figs. 14, 15) are also subject to certain variations in regard to the size and proportional length of the rays. In general we may say that the rays are slender, measuring only about 9 μ in thickness near the base. They are nearly entirely smooth or subterminally obsoletely rough; the ends are rounded or bluntly pointed.

The free distal ray varies in length from, say, 120 μ to 240 μ. It is scarcely distinguishable from the other rays except by its relative shortness or by the fact that it is often slightly less tapering towards the end. The paratangential rays are straight or gently bent and about 300 μ in average length. The proximal ray may be either shorter (fig. 14) or much longer (fig. 15) than the paratangentials. The former is the rule especially with those dermalia in which that ray ends free in the subdermal space, as is the case in such parts of the dermal layer as extend over incurrent apertures. The proximal ray is generally longer—at times twice as long or even longer—than the paratangentials, and the entire spicule thus becomes more or less

sword-like, at places where the dermal layer touches the parenchymal mass, into which the ray in question enters like a nail.

The dermalia are seen to extend over the membranous zone around the parietal oscula, forming the usual latticework right to the edge. Many of them in this situation have a very short proximal ray. In passing it may be mentioned that no more specially differentiated oscularia were found in this than in other species of the genus.

A much larger size as given above is attained by some—not all—sword-like dermalia on the cuff-edge as well as on the summits of parietal prominences, in intermixture with the prostalia occurring in these places (Pl. X, fig. 11). With the general growth in size of the entire spicule, the free distal ray especially undergoes elongation and development. It assumes a slender spindle-like shape, while the surface for nearly its entire length becomes roughened by the presence of microtubercles (Pl. X, fig. 13). I have measured such distal rays of 300 μ, 400 μ, 500 μ and more in length with a breadth of 22 μ and over at the thickest part. Thus, as before said, the dermalia approaches, and finally becomes indistinguishable from, the smaller prostal hexactins.

The *gastralia*, found in irregularly scattered distribution, are pentactins of moderate size, with the atrophied sixth ray indicated by a gentle swelling. The rays are straight or nearly straight, slightly tapering or uniformly thick (12 μ or less) throughout. End almost always rounded ; subterminally obsoletely rough. The paratangential rays are often of unequal length in the same spicule ; length up to 700 μ. They run not always along the extreme gastral surface, being sometimes overlaid by

parenchymal diactins. The unpaired distal ray is usually much more elongated than the paratangentials.

In exceptional cases, the gastralia seemed to be represented by thetactins or stauractins.

The *hexasters* are floricomes, graphiocomes and onychasters, thus perfectly agreeing in this respect with *R. phœnix* O. Schm.

The floricomes (Pl. X, figs. 5–7) are borne in the well-known manner on the distal ray of almost every dermalia. They are also common in the subdermal region where they take origin. The diameter measures 136–152 μ. They are therefore considerably larger than in *R. okinoseana* or in the specimen which I identify as *R. phœnix*. The principal is 13 μ long as measured from the axial center and 3 μ thick; it contains an axial canal extending to the very end which is slightly expanded. Five to eight terminals compose a perianth. This measures 13 μ across the basal swollen part; above the middle it narrows considerably (often to such an extent that the adjoining terminals almost touch one another), finally to expand to a width of about 50 μ. Each single terminal (fig. 6) is basally very thin but as broad as 5 μ just behind the terminal disc. The latter, as seen from the top (fig. 7), is 11 mm. long and 15 μ broad (teeth included). Its outer edge bears 5–8, moderately strong, recurved teeth. The rounded inner edge of the disc is plainly noticeable as such.

Graphiocomes of the usual appearance are occasionally found, likewise in the subdermal region. Of much more common occurrence are their detached terminals, the rhaphides, either scattered or still grouped in sheaves and found in various positions in the dermal layer (Pl. X, fig. 12). An intact graphiocome measures

200 μ in diameter. The principal is about 10 μ long, as measured from the axial center. The terminal sheaf is 12 μ thick, keeping nearly the same width throughout or only slightly expanding toward the outer end.

The *onychasters* (Pl. X, fig. 12) occur in abundance everywhere in the parenchyma. They are 80–96 μ in diameter, i. e., about as large as in *R. phœnix* but of more uniform size. From each short principal (9 μ long as measured from the axial center) there arise 3–5, thin, tapering, nearly straight and strongly divergent terminals. The finely attenuated end of these bears a whorl of 3 or 4, fine minute claws of just the same appearance as those to be described under *R. phœnix* (Pl. X, figs. 20, 21). In some onychasters, the terminals and the claws were found to be less fine than in others.

Finally, the rigid basal mass is composed of an irregular framework of siliceous beams (Pl. X, fig. 17). These are 20–35 μ thick ; smooth but with occasional microtubercles or prickles. The inclosed meshes are, though not always, rather wide (measuring up to 200 μ or more across). The framework is formed by synapticular fusion of not only diactin-parenchymalia but also of certain thick-rayed hexactins, the *basidictyonalia*, observed in so many other Lyssacina with hard bases (p. 232). This is proved by the presence of the hexradiate axial cross in the beams and also by such basidictyonalia in different stages of amalgamation as still retain their original external form.

REGADRELLA PHŒNIX O. Schm.

Pl. X, figs. 18–27; and Pl. XI.

Regadrella phœnix, Schmidt '80, p. 61; pl. VIII, figs. 6, 7.—Schulze '86, p. 39 (Rpr.).—Schulze '87, p. 84; pl. XIII, figs. 1–4.—Schulze '95, p. 34.—Topsent '96, p. 275; pl. VIII, fig. 1.—Schulze '99, p. 20; pl. III, figs. 3–6.

Trichaptella elegans, Filhol '85, p. 284; pl. VIII.

Rhabdodictyum delicatum, Topsent '92, p. 25; pl. V, fig. 1.

Regadrella phœnix O. Schm. has been reported from the following localities:

Near Lesser Antilles (Caribbean Sea): Santa Cruz, 453 m.; Barbados, 404 m. & 526 m. (O. Schm. '80). Between Sta. Lucia and St. Vincent, 514 m. (F. E. S. '99).

Near Azores: 861 m.) (Tops. '92), NW. of Saô Jorge, 1022 m. (Tops. '96).

Bay of Biscay: 1410 m. & 1220 m. (Tops. '96).

Coast of Morocco: 865 m. (Filh. '85).

Eastern Pacific: near Galapagos, 717 m. (F. E. S. '99).

If I am not mistaken in referring to this species the specimen, on which the following description is based, it is to be added to the above list: Coast of Chile, 3200 m.

The said specimen is contained in the zoological collection kept for show purposes on board the U. S. Fish-Commission SS. 'Albatross.' During the two visits she paid to Japan in

1896 and 1900, opportunities for the study of that specimen were given me through the courtesy of my friend, Dr. L. STEJNEGER, on the first occasion, and of Captain J. F. MOSER on the second. The only information I could obtain about it was the statement on the label: 'Venus' Basket, a siliceous sponge from 1800 fathoms. Station: Off coast of Chile.'

A good description of an authentic and well-preserved *R. phœnix* is still a desideratum. In fact only imperfect fragments of the species have as yet been studied with any care; hence, the somewhat unsatisfactory state of our knowledge. In my attempts to identify the 'Albatross' specimen, I found that it presented in its structure several points which seemed to be of importance as specific characters, but which were either uncertainly or not at all known from *R. phœnix*, or are perhaps quite wanting in that species. It is therefore with some degree of reserve that I refer the 'Albatross' specimen to *R. phœnix*.

GENERAL CHARACTERS.

The specimen (Pl. XI, figs. 1, 2) is of a tubular form, torn off at the lower end. Length about 240 mm., representing, I should judge, nearly three-fourths of the original entire size. Diameter at the middle about 75 mm.; that at the lower end about 50 mm. (It has previously been known that the species may attain a height of 500 mm.).

The wall is thin, not more than 3 mm. thick in the thickest part. It bends and falls in of itself when taken out of the spirit in which it is preserved.

The upper end is rounded, the lateral wall closing in slightly

all around toward the border of the flatly convex sieve-plate, which is encircled by an inconspicuous ridge-like *cuff*.

I should remark that this state of the upper end seems to be usual in *R. phœnix*, at least after a certain stage in its growth. SCHULZE's figure in the Challenger Report, taken from an authentic specimen given him by O. SCHMIDT, indicates just this condition of the upper end. And so do also the figures given by FILHOL of his *Trichaptella elegans*, which TOPSENT ('96) assumes to be identical with *R. phœnix*. Whether TOPSENT be correct or not in this assumption, it may nevertheless be presumed that, as he had before him some perfect specimens of *R. phœnix*, he had observed an agreement in configuration between these specimens and the above mentioned figures of FILHOL.

The *sieve-plate* in the 'Albatross' specimen is greatly damaged; originally it must have been approximately circular and about 30 mm. in diameter (Pl. XI, fig. 1). Of its beams there remain only those which must have formed the main support of the plate, and which are themselves supported by the strong spicular rays that correspond to the coronal rays of *R. komeyamai*. The beams that remain project inwards from the cuffed border, are 2–6 mm. apart at the roots, and are arranged on the whole like the spokes in a wheel. Several of them meet or nearly meet at the center but without uniting in this position. However, there are some which in their inward course become confluent with their neighbors, thus forming triangular meshes. In a few places they show lateral branches, or rather remnants of these, which originally might have effected a continuous communication between two adjoining radial beams.—It scarcely needs to be pointed out that the beams are, unlike the coronal

rays in *R. komeyamai*, bundles of spicules, similar to the parenchymal strands. Their free ends bear unmistakable signs of having been forcibly broken off. Whether a central nodal plate, such as is possessed by *Dictyaulus elegans* (SCHULZE '95), originally existed but had been torn away, can not be ascertained; but I think this much may be said, that the principal beams are in the main radially disposed and that the meshes are comparatively wide with angular corners. How far the radial arrangement of the main beams, consequent upon the strong coronal ray entering into their support, can be verified in typical specimens of *R. phœnix* from the Atlantic remains to be seen.

Parietal oscula (see Pl. XI, fig. 2), circular in shape and mostly measuring 3–5 mm. in diameter, perforate the wall at intervals of 5–10 mm, arranged in two intersecting systems of irregular, oblique rows. They are thin-edged as usual and occupy each the center of a flatly depressed area bounded by the main strands of the parenchymal skeleton.

Both the *incurrent* and the *excurrent canals* are visible on their respective sides of the wall as small and shallow depressions under 1 mm. in diameter.

The *dermal surface* had been much abraded, exposing the more superficial parenchymal bundles. However, the occurrence of well-developed ledges or of hillocks with prominent prostalia must evidently be entirely denied. The surface is on the whole even, or more properly, gently undulating on account of the low and broad swellings between the parietal oscula.

The dermal layer was found preserved in patches. In such places I have found the surface studded at intervals of 2–5 mm.

with small irregularly *papilla-like prominences*, not more than $1^1/_2$ mm. in height. These are evidently caused by the hydranth, invariably contained in them, of a commensal Hydrozoa which is harbored in the sponge-wall. The prominences were not observed in the uppermost region of the body only; whether as the result of abrasion or not, could not be determined. Under the hand-lens, their summits as also the free edge of the cuff appear to be spiny (Pl. XI, fig. 3). The spines, protruding for not more than half a millimeter, are found to be the distal rays of certain specially developed dermal hexactins.

Are the papillæ to be regarded as something of constant occurrence in the species? In consideration of what we know about the relation of the *Walteria* species to the commensal Hydrozoa (see anon, under *W. leuckarti*), this question is possibly to be answered in the affirmative. However, nothing like the papillæ, or the peculiarly modified dermalia (Pl. X, figs. 25–27) in connection with them, has before been described from *R. phœnix*.

The coarse *parenchymal bundles*, exposed on the external surface, pursue a sinuous course in oblique or in nearly longitudinal directions (Pl. XI, fig. 2). The bundles, more deeply situated and exposed on the gastral surface, take a course which is inclined to be transverse in direction, similarly as we have seen in other species of the genus.

In the upper part the principal bundles of the skeleton run obliquely right up to the sieve-plate border, exactly as is to be seen in the figure of *R. phœnix* given by SCHULZE in the Challenger Report.

Some bundles, but by no means all, extracted from the lower

part of the specimen exhibit the synapticular fusion of the megascleric elements. Much less frequently such fusion is to be met with in about the middle, and none at all still higher above. Were the base of the specimen preserved, just the same condition as has been known from *R. phœnix* in regard to the fusion of spicules in that region would undoubtedly have been found.

The said condition of the base admits, as was remarked by SCHULZE ('87), of the occurrence of several specimens growing one within another, each inner one representing a younger generation seated within the dead skeletal remnant of the preceeding generation. O. SCHMIDT ('80) observed such occurrences when he first described *R. phœnix*, which specific name he chose on that account. TOPSENT ('96) mentions a case in which as many as fine generations were represented in the manner noticed, and recently SCHULZE ('99) has added still another instance to the list. It scarcely needs to be remarked that this piling up, as it were, of successive generations, forms no specific peculiarity of the species. In *R. okinoseana* I have found it a very common occurrence that the young specimens are attached to the dead skeletal stump of the same species. So also the two individuals I have described of *R. komeyamai* are attached, not one within the other, but close together, side by side, on the basal mass of an individual long dead and destroyed.

SPICULATION.

The spiculation shows an especially close agreement with that of the species last described.

Excepting the large oxypentactins common to the sieve-plate

and the lateral wall, the *parenchymalia* are chiefly diactins with an occasional sprinkling of slender thetactins and of similar hexactins which have one axis greatly elongated in excess over the others.

While the thinner parenchymal strands consist solely of the thin filamentous spicules, the coarser ones contain large bow-shaped or boomerang-like oxydiactins, the *principalia*, in addition to the much more slender comitalia. The principalia may measure 50 mm. or more in length and 290 μ in thickness at the middle which is smooth and either gently curved or bent in an elbow-like manner. The finely attenuated ends are smooth-surfaced. In forming a bundle, the principalia are arranged side by side and one after another in overlapping series, each surrounded by a copious quantity of the comitalia.

The *comitalia* and all other fine parenchymal diactins are either annulated or cruciately knobbed at the center ; their ends rounded or conically pointed, often swollen and subterminally roughened to a greater or less degree.

The radial beams of the *sieve-plate*, which are to be considered as outward continuations of the parenchymal bundles, are supported by certain prolonged rays of large, unequally rayed oxypentactins (occasionally oxystauractins) arranged in a circle along the sieve-plate border. (Pl. XI, figs. 5, 6). Similar spicules in the same position and arrangement have been described by F. E. Schulze in *Dictyaulus elegans*, and by myself in *R. komeyamai* (see p. 259). The plane of the two complete and cruciately disposed axes is concave on the inner side, and on this side the sixth atrophied ray is always represented by a small, conical protuberance. The outwardly directed, unpaired ray is

relatively very short (not over 2 mm. in length) and is sometimes represented merely by a rounded boss. It enters into the support of the cuff.

Of the cruciate, paratangential axes, the one in longitudinal direction is the longest, reaching up to 30 mm. in length. The superior ray in this axis, i. e., the ray which goes into the composition of each of the radial sieve-plate beams, is in length about equal to or shorter than the inferior ray which is imbedded in the parenchyma of the lateral wall. The lateral rays in the transverse axis are always much shorter than either the superior or the inferior ray; sometimes they are as short as the distal unpaired ray. Thickness of the rays at base 250–475 μ. The superior and the inferior rays commonly thicken somewhat at a short distance from the central node, then gradually narrow again toward the finely pointed end.

The lateral rays, lying along the base of the cuff, run in association with just the same diactin elements as compose the parenchymal bundles of the lateral wall.

The superior ray is distinguished from all the rest by having a number of obsolete microtubercles widely and sparingly distributed over its surface (Pl. XI, fig. 7). The microtubercles are frequently only indicated. They disappear entirely towards either end of the ray. Along with the ray in question are found in a bundle bow-like oxydiactin-principalia and diactin-comitalia, to complete the parenchymalia of the sieve-plate (Pl. XI, fig. 8). Among the comitalia are not uncommonly found small and slender-rayed hexactins, which pass over into the shorter diactin-comitalia by a gradational series of intermediate forms.

In the Challenger Report F. E. Schulze gave large oxy-

pentactins as the principal parenchymalia of the species. Later ('99) he described for these strong oxydiactins bent in a boomerang-like manner. This apparent contradiction may be explained by assuming that on the first occasion he had before him the above-described oxypentactin of the marginal zone, which assumption is all the more likely since at the time only the upper end of the body was available for his study.

The *dermalia* (Pl. X, figs. 23, 24)—as they occur on the general surface, forming a delicate, quadrate-meshed latticework, the meshes measuring only about 240 μ in length of sides—are small, slender-rayed hexactins in which the distal ray is the shortest and the proximal ray, usually but not always the longest of all the rays. The former is only 60–90 μ long and scarcely ever exceeds 6 μ in thickness. It slightly broadens towards the rounded outer end, but never to such a marked degree as to give it a distinctly club-like form. The surface is rather sparsely provided with almost obsolete microtubercles. All the other rays taper gradually toward the bluntly pointed end. They are smooth all over or subterminally faintly rough ; straight or somewhat bent. The paratangentials are 150–250 μ long. The proximal ray is, as indicated above, usually much longer (fig. 23), but sometimes only about as long ; it may even be considerably shorter (fig. 24), as, for instance, in those dermalia situated on the membranous edge of the parietal oscula.

Dermalia of the above description have been hitherto unknown from the species and constitute one of the points which it is exceedingly desirable should be tested in specimens from the Atlantic.

The dermalia present themselves in specially large size and strong development on the papillæ which as we have seen stand in relation with the hydranth of the commensal Hydrozoa, as well as on the free edge of the cuff (Pl. X, figs. 25–27 ; Pl. XI, fig. 4). They give to these parts the spiny appearance already mentioned and might not improperly be called prostal hexactins, were it not for the comparatively insignificant length attained by the freely projecting, distal ray.

On the *papillæ* (Pl. XI, fig. 3), the dermalia are sword-shaped hexactins, many times larger than the ordinary dermalia and with the distal ray swollen into a fusiform or a club-like shape (Pl. X, figs. 18, 25–27). This ray generally measures 600–870 μ in length and 45–80 μ in greatest breadth. Its lateral contours are frequently not symmetrically even. Close to the rounded or bluntly pointed end the surface is rough on account of the presence of either pointed or rounded microtubercles. Sometimes the ray is smooth nearly all over. All the other rays (11–27 μ thick near base) are tapering, subterminally sparingly microtubercled, and end conically or obtusely pointed. The paratangentials are comparatively very short and often of unequal length in the same spicule. The long proximal ray, which dips into the parenchyma accompanied with diactin-comitalia, may be 2 mm. or more in length ; occasionally as short as the paratangentials. It is not infrequently more or less distinctly bent in its course.

From Pl. X, fig. 22, or by comparing figs. 23–24 with figs. 25–27 in the same plate, will be obtained a fair idea of the difference in size between the ordinary dermalia and those in a group around the Hydrozoan body. The paratangentials of the latter kind of dermalia generally lie somewhat below the general

level of the dermal layer. I think the two kinds are connected by forms of intermediate shapes and sizes.

Of specially strong development are also the dermalia which lie crowded on the cuff-edge. Here they are again sword-like hexactins (Pl. XI, fig. 4), differing from the papillar dermalia in being somewhat stronger on the average and in having the distal ray slightly differently characterized. They may measure in total length 3 mm. or more, of which 1—1¼ mm. belong to the distal ray. This ray may reach 100 μ in thickness at base. It is tapering, though the lateral contours are not always even or straight. It bears low and somewhat scaly tubercles which are either confined to the end or extend over its outer half. In the latter case they are notably smaller and more crowded towards the bluntly pointed end of the ray. Paratangential rays may be as long as 800 μ; their pointed ends rough or nearly smooth.

Both SCHULZE and FILHOL have figured bristle-like prostalia projecting to a length of several millimeters on or around the cuff. I have not found the like in the specimen examined by me. The said prostalia are, according to SCHULZE, the free distal rays of hexactins ('87, pl. XIII, fig. 2), which resemble some of the marginal dermalia I have seen, except that they are much larger.

The *gastralia* are pentactins somewhat larger than the ordinary dermalia and distributed without regularity in their arrangement. The paratangential rays are usually unequally long in the some spicule; up to half a millimeter or more in length; about 10 μ thick for the greater part of their length; more or less curved; subterminally somewhat swollen and rough; end rounded.

The unpaired ray is usually much longer and more pointed at the end than the paratangentials.

Of the *hexasters*, the *floricome* (Pl. X, figs. 18, 19) is found in abundance in the periphery of the wall, now and then borne on the end of dermal distal rays in the usual way. Diameter 100–115 μ, which size nearly corresponds to that of the same rosette taken from O. SCHMIDT's type specimen and figured by SCHULZE in the Challenger Report. The disc at the end of each principal is convex on the outer side. Terminals 5–8 in a perianth. Terminal disc with 4 or 5, moderately strong teeth on the outer edge; the inner edge in profile view is indicated by a hump-like bend of the contour-line at that place.

The *graphiocome* in an intact state was rarely observed, but the rhaphides detached from it were found in tolerable abundance, either scattered singly or still preserving their sheaf-like arrangement. They mostly adhere to the dermalia; otherwise, they lie about free in the most peripheral region of the wall. Length of rhaphides 95 μ. Relics of the graphiocome, consisting only of its principals with discs at the ends, have been occasionally met with. Principals 10 μ long; rather slender. Except in a specimen from the Galapagos (F. E. SCH. '99), the graphiocome seems to have hitherto been overlooked.

The *onychaster* (Pl. X, figs. 20, 21) closely resembles the same of *R. komeyamai*. It is very abundant, especially in the deeper parts of the wall. Diameter 64–92 μ. The fine, tapering terminals number 3 or 4, rarely 2 or 5, to each principal. The short, exceedingly fine, backwardly arched, terminal claws seem to number 3 to each terminal ray. They may be easily over-

looked, and the rosette taken for an oxyhexaster, unless a high power be used in examination.

Nobody has given the measurement of the onychaster from Atlantic specimens. However, by computation from the scale of the figures given by Schulze and Topsent, the diameter should be 64–90 μ, a range of variation well agreeing with that in the 'Albatross' specimen.

Walteria F. E. Sch.

So far as known at present two species make up this genus, viz., *W. flemmingi* F. E. Sch. and *W. leuckarti* Ij.

The generic diagnosis would be :

Euplectellids of saccular or tubular shape, firmly attached by the expanded base; with oscula on the sides; the surface with simple or branched processes (produced by a commensal Hydroid colony). Principal parenchymalia, diactins; intermedial parenchymalia of small, spinous oxyhexactins. The hexasters are: Floricomes (which may be wanting) ; spherical discohexasters with numerous terminals ending in an arched disc; onychasters; and graphiocomes.

The spiculation indicates the close affinity of the genus to both *Tœgeria* and *Regadrella*.

The differential characters of the two species are :

a. Saccular, the wall consisting of a wide-meshed latticework of beams. With floricome. Spherical discohexaster about 62 μ in diameter... *W. flemmingi* (N. of Kermadec Is.).

b. Tubular, with numerous side-branches giving a tree-like form. Without floricome. Spherical discohexaster 75–90μ in diameter..... *W. leuckarti* (Sagami Sea).

WALTERIA LEUCKARTI Ij.

Pls. XII & XIII.

Walteria leuckarti, Ijima '96 p. 251.
Hyalodendron navalium, Moore '98.

The exquisitely tree-like Euplectellid from Japan recently described and figured by J. P. Moore under the designation of *Hyalodendron navalium* n. gen., n. sp., is indubitably identical with my *Walteria leuckarti* previously described in the 'Zoologischer Anzeiger.' The brevity of my description may have had much to do in causing Moore's failure to recognize the identity. The creation of a new genus to receive the species is, in my opinion, inadmissible. The description given by Moore is on the whole good, but requires some important additions and corrections.

Numerous specimens have passed through my hands. The exact localities in the Sagami Sea, where specimens of the species have been obtained by Kuma, are as follows:

Outside Okinosé, 717 m. (500 *hiro*=392 fms.).
Near Mochiyama, 1000 m. (700 *hiro*=546 fms.).
Homba, 500–572 m. and over (274–313 fms. +).
Gokeba, 572 m. (400 *hiro*=313 fms.).

Fragments and grains of tufa attached to the basal disc attest the nature of the bottom.

Once at Gokeba, a haul of the long-lines brought up large fragments of four different individuals at a time. From Outside

Okinosé I have a specimen consisting of two individuals whose stems had come in contact crosswise and had fused together. These cases may indicate that the species grow close together side by side in certain localities.

The species has as yet never been obtained in the Sagami Bay, north of the Okinosé ridge.

General Characters.

The three specimens shown in Pl. XII, reduced to $^1/_4$ natural size, will give a good idea of the general appearance of the sponge. It resembles in a measure a Cryptomeria or a fir-tree denuded of leaves. The body may be said to consist of the basal disc, the stem and the lateral branches.

The *basal disc* is large, solid and compact. It may measure 120 mm. or more in diameter and about 3 mm. in thickness at the blunt-edged margin. The thickness increases towards the origin of the stem. The disc may be irregularly shaped conforming itself to the character of the rocky substratum.

On the superior surface there are usually seen in small numbers and in indefinite positions thin and sharp edged openings, which may be as large as the oscula on the stem but usually are smaller. They lead into shallow cavities, the wall of which may again show perforations penetrating for some distance into the hard basal mass. These are evidently excurrent canals, the external openings being undoubtedly oscula. This leads us to assume that the flagellated chambers occur even in the disc and that the circulation of water takes place here in a manner similar,

to that in the upper part of the sponge, though probably with less energy.

From near the center of the basal disc arises the stem, the sponge-body proper, which is tubular. This is usually more or less bent. In large specimens it may reach a height of one meter. Its thickness at its base may about equal that of one's finger, but is somewhat thinner in average specimens (11–12 mm. dia.). As a rule it slightly narrows above for a short distance, thence either to keep up a nearly uniform caliber or to appreciably thicken again (up to 17 mm.) towards the middle section of the stem, where the lateral branches are in strongest development. Further above, the stem shows a gradual tapering to the apex. I find this end broken off in most cases. In the specimen of Pl. XII, fig. 3, it is preserved, showing that the apex tapers off to a point and is closed. The cross-section of the stem is on the whole circular in outline; sometimes rather polygonal.

A well developed lumen, i. e., the *gastral cavity*, extends through the stem from base to apex. Thickness of wall in the middle of body 1.5–2.5 mm. Towards the base the wall becomes much thicker at the expense of the caliber of the internal lumen.

The moderately large *oscula*, to be seen here and there on the wall, are sometimes round but more generally oval or elongate oval apertures with the longer diameter disposed in the longitudinal direction. They are by no means uniform in size; the largest may measure 10 mm. in the longer diameter. The ocular margin is sharp-edged, scarcely thicker than a sheet of paper and is usually raised into a low crateriform or lip-like rim.

The distribution of oscula on the stem is quite irregular.

Sometimes but a narrow bridge-like space intervenes between two adjacent oscula; more frequently are they situated more than 100 mm. and at times even 200 mm. apart on the same side of the stem. Their total number is therefore never very great. In a large specimen with a height of 855 mm., I have counted in all not more than 25 oscula on the stem. The uppermost osculum may lie within a distance of 10 mm. or so from the apical end. Inferiorly, an osculum may occur right at the stem-base and, as before mentioned, even on the basal disc. There apparently exists no definite relation between the distribution or size of oscula and the development of lateral branches.

Seen with the naked eye or under a lens, the surface of the lower stem-end shows the same structural character as the basal disc,—that is to say, a densely interwoven texture of fine spicules intersecting in all directions. On these parts, a loose superficial tissue is usually entirely wanting. Such a tissue generally begins to exist on the stem a few centimeters from the base and covers the rest of the sponge parts in a thin, but by no means uniformly distributed, layer. This tissue, together with warty protuberances on the stem and the branches, gives to the sponge an appearance fittingly described by MOORE to be, 'as if the specimen had been dipped into a thick soap lather, which had been allowed to dry on its surface.'

Through that covering layer can be plainly observed the outer spicular bundles of the parenchyma, traversing the stem on the whole in a longitudinal direction. They are of varying thickness and closely set, frequently uniting and again separating in their course or sometimes intersecting one another at low angles.

On the other hand, the gastral surface of the wall (see Pl. XIII, fig. 5) shows the inner system of weaker and more widely set parenchymal strands which are directed in the main transversely or obliquely. Thus it will be noticed that the general arrangement of the parenchymal strands is the same as I have described for *Regadrella*.

The small irregular meshes on the gastral surface, formed by the intersecting of parenchymal strands, are each occupied by a shallow or pit-like depression, the excurrent canal.

What now give the most characteristic feature to the species are the branches and wart-like tuberosities, which latter occur on both the stem and the branches but more numerously on the branches.

Let it at once be stated that the branches arise by growth from the wart-like tubercles, and that the production of both is evidently dependent upon the commensal Hydroid colony tenanting the sponge-wall, as has been maintained by F. E. Schulze also in the case of certain tubular structures in *W. flemmingi*. The branches in *W. leuckarti* are in a sense comparable to, although genetically different from, the ledges of *Euplectella*, the stem being the most essential part of the body.

The tubercles are sometimes low and not at all pronounced; sometimes distinctly wart-like or even tubular. Seen under a lens, they present a hispid exterior on account of the dermal hilt-rays. (Pl. XIII, figs. 20, 21). Their general appearance, especially as they stud the branches, reminds one of the polyparies of a Madreporarian skeleton, and that all the more, since each tubercle has a small opening in its summit. The more prominently developed tubercles have more than one opening besides

the terminal one. Each such opening leads into a small cavity (Pl. XIII, fig. 21 ; *cav. hy.*) which invariably harbors a hydranth of the commensal Hydrozoa. The cavity serves the part of a hydrotheca to the naked hydranth. Special canals proceeding from it for the reception of the branched cœnosarc can not be perceived. According to KUMA's statement, the tips of the tubercles in the fresh state present a pinkish color, which probably belongs to the Hydrozoa in question.

There exist on both the stem and the branches all sorts of transitional stages between simple tubercles and such as deserve to be called inceptional branches or twigs. The growth into the latter is evidently initiated by a multiplication of the hydranths and by the formation of new openings for these, and eventually of new tubercles. So long as they are small and simple, the tubercles are made up entirely of the loose, superficial sponge-tissue and can therefore be easily rubbed off. As they progress in their development into branches, they acquire for their support an axial core of parenchymal strands branching out from the same of the parts on which the developing branch is borne (see the lower end of fig. 20). Pl. XII, fig. 2 shows a skeleton in which the superficial loose tissue together with the tuberosities had been entirely scraped off.

The branches, varying in thickness from less than 1 mm. to $3^1/_2$ mm., spring out on all sides of the stem, though exhibiting different degrees of development in certain parts as will soon be pointed out. They generally arise from the stem at nearly right angles. When somewhat obliquely inclined, they are directed superiorly about as often as inferiorly. They are usually nearly straight, though I have found many of the branches almost uniformly curved upwards in one specimen and downwards in another.

The branches emanating from the stem may be simple and unbranched, in which state they may sometimes attain a length of 40 mm ; but more usually are they provided with secondary branches, developed in number and length proportionally to the primary branch, which, when large, may bear even tertiary branchlets on its secondaries. The secondaries and tertiaries shoot out more or less inclined towards the apex of the branches bearing them, frequently forming with the latter an angle of about 45°.

On the lower portion of the stem, the branches are obliterated and are represented by compact stumps. The longer stumps may be frayed out at the outer end into a tuft of separate needles. Such remnants of the branches are sometimes found even on the basal disc. Complete branches begin to exist at some distance from the basal end. They are at first all small. Larger and more complex branches add themselves to the smaller, in a generally gradual development, towards the middle of the stem. Thence towards the upper end the branches again become continually shorter, and finally they become so very short that the general form of the sponge gradually narrows towards, and is pointed at, the apex (Pl. XII, fig. 3). In a very large specimen (855 mm. high), one of the largest branches was 200 mm. long, bearing numerous secondary branches up to 55 mm. in length.

I have said the branches arise on all sides of the stem ; but it must not be supposed that they are equally developed in all directions. As a constant feature seems to be the situation of the larger branches oppositely along two sides of the stem. As the result of this arrangement the entire sponge is of a more or less flattened form : it is laterally compressed, if one may so express it. It is also distinctly noticeable that the secondary branches

are best developed in the plane of the primary branches bearing them. The symmetry and regularity in form of the entire sponge is however usually much disturbed by the bending and twisting of the stem as well as by the not uniform development of the lateral branches.

In certain specimens, as an occasional occurrence a branch may be swollen, either terminally or elsewhere, into an irregular mass of considerable thickness. For instance, the specimen of Pl. XII, fig. 1 shows such swellings in at least two places. Cutting one open, I found no free cavity within but a space traversed by loose parenchymalia, in which was imbedded the body of a small animal—probably an Annelid. I think the swellings are always mere abnormalities caused by certain extrinsic objects. The process of their formation may in a measure be compared to that by which all the branches arise in connection with the commensal Hydrozoa and yet the latter comes near to being intrinsic on account of its invariable presence.

In some specimens it is not at all uncommon to observe a thin web-like expansion of the spicular tissue at the axils of the branches. One specimen which I have seen was particularly distinguished by the great abundance of the web-like plates not only on the branches themselves but also between these and the stem. On the other hand, a number of specimens nowhere showed a similar development.

Spiculation.

The *parenchymalia* are almost exclusively diactins of various sizes. Very rarely among the *accessoria* there occur spicules

with a greater number of rays, as, for instance, hexactins with one of the axes elongated considerably more than the others.

The oxydiactin *principalia* may measure 35 mm. in length and 120 μ in breadth at the middle. They are usually nearly straight and smooth throughout. They are present as usual in all sizes, grading down to fine *accessoria* which occur either as comitals or singly by themselves. The accessoria are of only 7–11 μ breadth, either plain or annulated at the center, and subterminally swollen and rough-surfaced, the extreme end being rounded or obtusely pointed.

At the juncture of a primary branch with the stem, the axial parenchymal bundle of the former joins the outer bundles of the latter. At the root of the branch some of the fibers penetrate for only a short distance into the said parietal bundles; others are seen to spread out in all directions among these. A similar arrangement obtains at the origin of secondary and tertiary branches.

The coalescence of the parenchymalia by simple fusion as well as by numerous synapticulæ is carried on to a great extent in the stem. Only for a short stretch at the apical end the parenchymalia are all loose. The ankylosis is especially dense nearer the gastral surface and towards the basal end. It extends into the base of the primary branches and often farther outwards, but seldom into the secondary branches.

The greater part of the *basal disc* is composed of parenchymal diactins disposed not in strands but rather in a feltwork-like arrangement. They are compactly soldered together in a close-meshed framework. The compactness increases from the superior surface inwards. On the inferior surface, in direct contact with

the substratum, there is the usual reticular plate. This is thin and has small roundish meshes, measuring 20–40 μ across.

Scattered among the parenchymal megascleres are found small, slender-rayed and spinous oxyhexactins (sometimes oxypentactins by suppression of a ray). (Pl. XIII, figs. 18, 19). Doubtless we have here the same intermedial microxyhexactin which is known from *Regadrella okinoseana* (Pl. VIII, figs. 24–26), *Tægeria pulchra* and *Dictyaulus elegans*. The spicule in question generally measures 190–260 μ in axial length, the rays being only about 4 μ thick close to the base. Numerous small spines beset the entire length of the rays; they are directed somewhat obliquely outwards, though there exist others which stand out nearly or quite vertically. They become obsolete towards the finely pointed ends of the rays. The oxyhexactins thus characterized are not very numerous in the stem or in the branches. They occur in greatest abundance in the upper superficial layer of the basal disc.

The *dermalia* (Pl. XIII, figs. 6–9, 21) are exquisitely sword-like hexactins which are closely and rather indiscriminately set together, so that the paratangentials of separate dermalia do not form a regularly meshed latticework nor are they arranged all in the same level. They vary considerably in respect of size and of the relative development of their several rays. Those of the larger size measure 1 mm. or somewhat more in total length, the proximal blade-ray being five or six times as long as the distal hilt-ray. Such a large size is attained especially by those dermalia which enter into the composition of the wall of the wart-like tubercles. This reminds us of the tubercles of similar

nature and structure in *Regadrella phœnix* (p. 274). In other places the dermalia are usually much shorter—sometimes only about half as long, the blade-ray being of about twice the length of the hilt-ray. Thickness of rays at base 4 μ in the slender-rayed forms, but as much as 10 μ in the more stoutly developed ones.

The hilt-ray, 165–250 μ long, gradually thickens distally, finally to contract again and to terminate in an acute or obtuse point, rarely in a rounded knob. Thus, it is of a slender club-like shape. In a large specimen of the spicule, the swollen part may be 20 μ thick, i. e., about twice as broad as at the base. The surface is rough on account of low scaly microtubercles which gradually lose themselves toward the base of the ray. The roughness may be obsolete, especially on the more slenderly developed hilt-ray.

The paratangential rays, 80–200 μ long, are usually slightly broadened toward the end, which is sparingly microtubercled and obtusely pointed. They are not always quite straight, nor of the same length in the same spicule.

The proximal blade-ray tapers towards the pointed and faintly roughened end. It is not infrequently bent in adaptation to the circumstances of its occurrence.

As *gastralia* (Pl. XIII, fig. 10) are to be considered pentactins of medium or small size, found isolated and by no means numerously on the inner surface of the stem-wall. The paratangentials are usually 90–145 μ long and about 8 μ thick at base, while the distally directed, unpaired ray is about twice as long or longer. All the rays are smooth except near the conically or bluntly pointed end. A knob on the proximal side of the spicular center represents the atrophied ray. Moore's statement

('98, p. 433) that the gastralia are sword-shaped hexactins like the dermalia is not corroborated by the facts.

The *hexasters* of the species are the spherical discohexaster, the onychaster and the graphiocome. Remarkable is the absence of floricomes, which should be present in *W. flemmingi* in addition to all the three kinds of hexasters above-mentioned.

The spherical discohexaster (Pl. XIII, figs. 12–14), which is of great beauty and closely resembles the same of *W. flemmingi* in appearance, is found in great abundance, especially in the periphery inside the dermal paratangentials. Frequently it is found also outside these and sometimes even borne on the tip of dermal hilt-rays after the manner of floricomes in other Euplectellids. In deep parts of the sponge the discohexaster is wanting, or at any rate quite scarce.

In diameter the discohexaster measures 75–90 μ. Each short and rather slender principal bears at the outer end a plano-convex or nearly hemispherical disc (fig. 13). From all over the outer arched surface of this disc spring out numerous terminals, which are slender at base but gradually thicken outwards, finally to end with a watch-glass-like or hemispherical, marginally minutely serrated, terminal disc of about 4 μ diameter (fig. 14). It is difficult to determine the number of the terminals. In well developed cases, there must be to each principal thirty or more of them in a diverging bunch. In each bunch the more peripherally situated terminals are gently curved at base, while the central ones are straight. All the terminals diverge outwards in such a way that the terminal discs are uniformly distributed over the entire surface of the exquisitely spherical hexaster.

The delicate *onychaster* (Pl. XIII, figs. 15–17) is of much the same appearance as in *W. flemmingi*. It is rather rare, at any rate not common in all parts. While in most preparations it required a prolonged search to discover one, in others several were found side by side among the parenchymal diactins. This gave me the impression that the onychasters were in the main more deeply situated than the spherical discohexasters, though sometimes both occurred in intermixture.

Diameter 68–84 μ. The principals are very short, thick and swollen at the ends; each bearing 3–6 (rarely more), exceedingly fine and strongly divergent terminals. These arise from the principals without regularity in arrangement, not in a whorl (fig. 16). They generally taper towards the outer end, which is capped by a whorl of gently recurved, minute claws, usually 4 or 5 in number. The cap, though somewhat more strongly developed in some cases than in others, is ordinarily so small as to require careful observation under a high power in order not to overlook it. In several instances the terminals revealed no claws even when examined under the immersion system, but seemed actually to end with a minute pinhead-like knob. Moreover, the excessively fine outer ends of the terminals easily break off; so that the chances of the hexaster in question being erroneously taken for an oxyhexaster are great. Moore seems to have fallen into this error.

The *graphiocome* (Pl. XIII, fig. 11) is of typical form. It is very large, reaching almost 450 μ in diameter. Sheaf of rhaphidial terminals 200 μ long and 20 μ broad; the central, hexradiate principals 26 μ in axial length. As usual the graphiocomes are confined to the periphery of the sponge. In the perfect

state they are but seldom seen. Common however and in places quite abundant are the more or less disintegrated terminal sheaves which have separated from the mother-rosette and taken up a superficial position, lying vertical to the external surface along with the radial rays of the dermalia. Moore has failed to recognize the graphiocome in its entirety. By him the terminal rhaphides have been mentioned as 'acicular diacts,' while its central part which remains after the loss of the terminals has been taken by itself for a special kind of rosette.

Miscellaneous Notes.

All the specimens at my disposal were not in a fit state for a study of the soft parts. It could however be determined that the chamber-layer extends to the extreme end of the branches; further, that the ectosomal surface, lying some distance above the dermal paratangentials, is lifted into little conuli by the ends of the dermal hilt-rays (Pl. XIII, fig. 21).

Pl. XIII, fig. 4 shows a case of monstrosity in which the superior end of the stem is dilated into an irregularly pyramidal, compressed and thin-walled sac. The wall is perforated by a number of typical oscula. This anomaly had evidently arisen in connection with the reparative growth after the stem had sustained an injury in that part.

With respect to the commensal—possibly symbiotic—Hydrozoa, the state of preservation was in no case such as allowed an exact investigation into its characters. But this much could be observed: that each hydranth possesses numerous finger-like tentacles

and inferiorly passes, without sharp demarcation, into a stalk-like portion of the branched cœnosarc, which traverses the parenchymal tissue of the stem-wall and of the branches. The cœnosarc is 30–60 μ thick and apparently solid, though probably in fact tubular. Its branches possibly undergo anastomoses. In places it seemed to bear shorter or longer, blindly terminating branches which were sometimes swollen and club-like at the free end. These are probably early stages in the development of new persons by budding. A perisarc is wanting to the entire colony (gymnoblastic). Nestle-capsules oval-shaped and very small, measuring scarcely 5 μ in length.

The Hydrozoa is at any rate closely similar to the species inhabiting *W. flemmingi*, which has been figured by F. E. Schulze in the Challenger Report, Pl. XI, fig. 4. It is clearly different from either *Stephanoscyphus mirabilis* Allm (=*Spongicola fistulosa* F. E. Sch., known to inhabit several Monaxonid species) or *Amphibrachium euplectellæ* F. E. Sch. ('80).

F. E. Schulze, when describing the external from of *W. flemmingi*, had some doubts as to whether he had to do with a normally shaped specimen, or not rather with one essentially modified on account of the presence of the commensal Hydrozoa. He was apparently led to entertain this doubt from a certain Adriatic *Myxilla* which is normally of a compact bulbous body, but acquires a shape like a tuft of the common heath when invaded by *Stephanoscyphus mirabilis*. As for *W. leuckarti*, I think the shape ascribed to it in the above, and its association with the Hydrozoa, may fairly be said to be constant, since, in more than a score of specimens, not a single case has been observed that suggested the contrary.

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N. B.—To my regret I have inadvertently failed to get access to the two following works:

W. Marshall. Spongiologische Beiträge. Festschr. z. 70sten Wiederkehr d. Geburtst. v. R. Leuckart. Leipzig, 1892.

C. Gravier. Sur une collection d'éponges (Hexactinellides) du Japon. Bull. Mus. d'hist. nat. Paris. T. V, no. 8, pp. 419–622.

The former paper, as known to me through an abstract, should touch upon matters which demand attention in relation to the morphology and physiology of the Hexactinellida. The latter paper may possibly contain notes on some of the species described in this Contribution. I beg indulgence for any omissions in reference to these works.—I also very much regret that I have not been able to benefit by Minchin's 'The Porifera' (in Lankester's Treatise on Zoology), the appearance of which work has become known to me too late to admit of my securing a copy of it before finishing the printing of this Contribution.

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PLATE I.

Euplectella imperialis Ij.

Plate I.

Euplectella imperialis Ij.

All figures in reduced scale of size.

Fig. 1. An old specimen, 588 mm. long, of fully mature form.

Fig. 2. A specimen, 491 mm. long, in which the upper part had not yet attained full size.

Fig. 3. A rather young specimen, 245 mm. long.

PHOTOGRAPHED BY THE BRITISH MUSEUM

PLATE II.

Euplectella imperialis Iɪ.

Plate II.

Euplectella imperialis Lj.

Fig. 4. Upper end of a specimen, 465 mm. long., in which the wall is still growing in that part. Nat. size.

Fig. 5. Portion of the upper end of a full-grown specimen, seen from the gastral side. Nat. size.

Fig. 6. The youngest specimen in the Sci. Coll. Mus. Body 30 mm. long. Nat. size.

Fig. 7. A young specimen, 72 mm. long. Nat. size.

Fig. 8. Portion of the sieve-plate and cuff, from a full-grown specimen. Reduced to $^2/_3$ nat. size.

Fig. 9. Skeletal tube of a moderately large specimen, after washing away all the loose tissues. Nat. size.

Fig. 10. Floricome at an early stage of developing terminals. 440×.

Fig. 11. A more advanced stage of same (sigmatocome stage). 440 ×.

Fig. 12. A still more advanced stage of same. 440 ×.

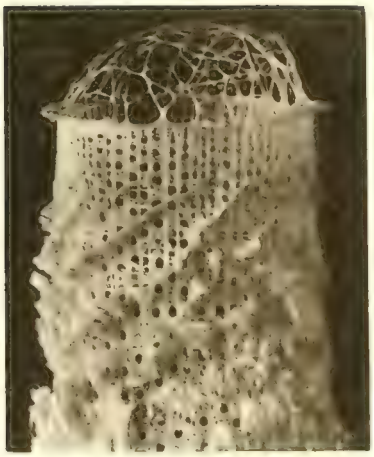
Fig. 13. Graphiocome in an early stage of developing terminals (rhaphides). 440 ×.

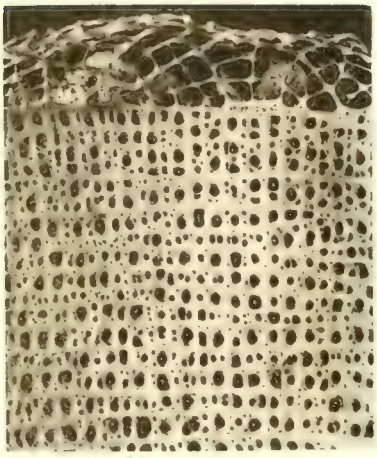
Fig. 14*a–d*. Different stages in the development of floricome-terminals. 1000 ×.

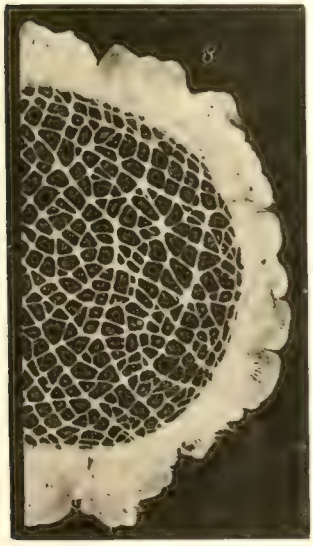
Fig. 15. Oxyhexaster. 440 ×.

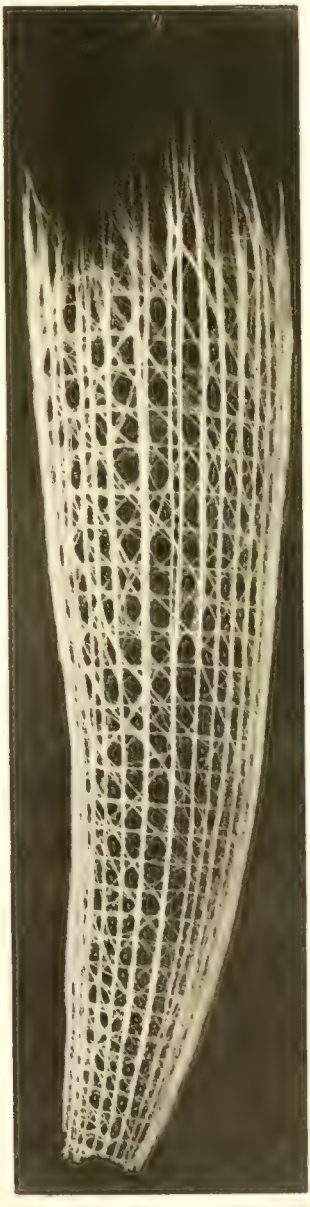
Fig. 16. Lower end of a basal anchoring spicule. 100 ×.

Fig. 17. Oscularia in situ. To the right, the edge of the oscular membrane. 100 ×









EUPLECTELLA IMPERIALIS O.

PLATE III.

Euplectella marshalli Ij.

Plate III.

Euplectella marshalli Ij.

Figs. 1–3. Three full-sized specimens in about half natural size.

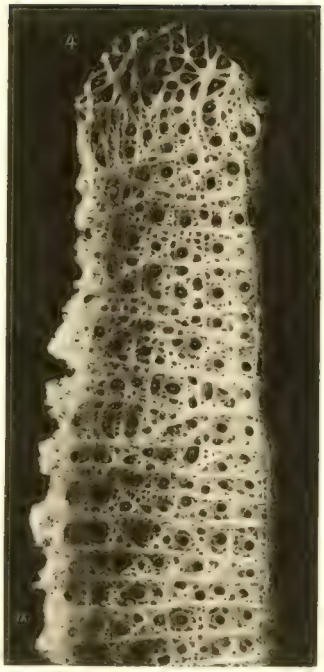
PLATE IV.

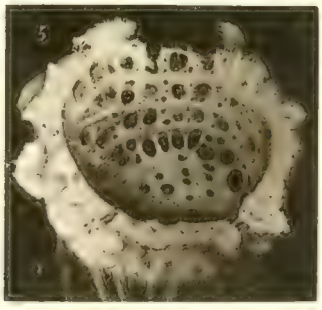
Euplectella marshalli Ir.

Plate IV.

Euplectella marshalli Ij.

Fig. 4. Gastral view of the wall. Sieve-plate at the upper end. Nat. size.
Fig. 5. Showing the bottom-plate. Photo. from a drawing. Nat. size.
Fig. 6. A young (22 mm. long), before the breaking through of parietal oscula. Nat. size.
Fig. 7. Skeleton of a young specimen (32 mm. long). Nat. size.
Fig. 8. A young specimen, 42 mm. long. Nat. size.
Fig. 9. A young specimen, 63 mm. long. Nat ciz».
Fig. 10. Floricome. 440 ×.
Figs. 11–13. Three stages in floricome development. 440 ×.
Fig. 14. Terminal of the immature floricome shown in fig. 13. With inceptional teeth. 1000 ×.
Fig. 15. Sieve-plates of two young specimens (39 mm. & 48 mm. long); seen from above. 2×.
Fig. 16. Dermalia of an average size. 300 ×.
Fig. 17. Oxyhexaster. 400 ×.
Fig. 18. Young oxyhexaster. 440 ×.
Eig. 19. Portion of a graphiocome. 440 ×.
Fig. 20. Portion of a graphiocome after the loss of the terminals. 1000 ×.
Fig. 21. Lophocome. 440 ×.
Fig. 22. Space between the apopyles (*ap.*) looked at from the excurrent side. 440 ×. *c.m.*, connecting membrane betw. the apopyles. *m.m.*, marginal membrane of the chamber-wall. *tr.*, trabeculæ.
Fig. 23. A portion of the dermal membrane. A trabecula expanded into a film-like band. 1000 ×. *tr.n.*, trabecular nucleus. *th.*, an old thesocyte.
Fig. 24. Portion of a thesocytal mass, showing the development of thesocytes from archæocytes (seen on the left). From a section stained with borax-carmine. 440 ×.
Fig. 25. Four thesocytes from above. 1000 ×.
Fig. 26. Lower end of a basal anchoring spicule. 150 ×.
Fig. 27. Oscularia in situ. Below, the oscular sdge. 50 ×.
Fig. 28. Section through the wall. 25×.—*a.cl.*, archæoeyte congeries. *ch.l.*, chamber-layer. *ex.tr.*, external trabecular layer. *in.tr.*, internal trabecular layer. *os.m.*, oscular membranc. *osc.*, oscularia.





EUPLECTELLA MARSHALLI II

PLATE V.

Euplectella marshalli Ij.

Plate V.

Euplectella marshalli Ij.

Figs. 29, 30. Early stages in the development of floricome. The principals inclosed in the scleroblast mass. Borax-carmine. 1000 ×.

Fig. 31. Portion of a mature floricome, still with the scleroblast-mass. Borax-carmine. 1000 ×.

Figs. 32–34. Stages in the development of graphiocome. Borax-carmine. 1000 ×.

Fig. 35. Optical section through the terminal sheaf of a developing graphiocome. Borax-carmine. 1000 ×.

Fig. 36. A small portion from the periphery in a section through the ledge, showing the conuli supported by dermal hilt-rays, the cobweb of trabeculæ, &c. Borax-carmine. 300 ×.—*a.cl.*, archæocyte-congeries. *arch.*, archæocytes. *ch.*, fundus of flagellated chamber. *s.c.*, subdermal cavity. *th.*, thesocytes.

Fig. 37. Chamber-wall (reticular membrane). Acid-fuchsin. 1500 ×. Above, the membrane is shown as out of the focus; the flagella are here visible either sidewise or in optical sections. The central dot in the choanocyte nuclei represents the origin of a flagellum. Below, at the right corner, four archæocytes (*arch.*)

Fig. 38. Same with coarse refractive granules in the protoplasm. Acid-fuchsin. 1500 ×.

Fig. 39. Apopylar edge of the chamber-wall. Borax-carmine. 1500 ×.—*ch.n.*, choanocytal nucleus. *m.m.*, marginal membrane. *tr.*, trabecula. tr. n., trabecular nucleus.

Figs. 40, 41. Choanocytes in profile view. Acid-fuchsin. 1500 ×.

Fig. 42. Same in surface view, combined from views obtained at different foci of the microscope. Acid-fuchsin. 1500 ×.

Fig. 43. Optical section showing incurrent lacunar space between four chambers. Borax-carmine. 1500 ×.—*m.r.*, membrana reticularis. Other letterings as in figs. 36 & 39.

Fig. 44. Groups of peculiar rod-like bodies (probably not belonging to the sponge). Borax-carmine. 1500 ×.

Fig. 45. Trabecula from a certain specimen, with egg-like cells (*x*) of various sizes. Borax-carmine. 1000 ×.—*tr.n.*, trabecular nuclei.

EUPLECTELLA MARSHALLI Ij.

Lith. Koshiba Tanda Tokyo Japan

PLATE VI.

Euplectella oweni Herkl. & Marsh.

Plate VI.

Euplectella oweni Herkl. & Marsh.

Fig. 1. A specimen with comparatively prominently developed ledges. $^2/_3$ nat. size.

Fig. 2. Upper end of the largest specimen in the Sci. Coll. Mus. seen from the narrower side. $^2/_3$ nat. size.

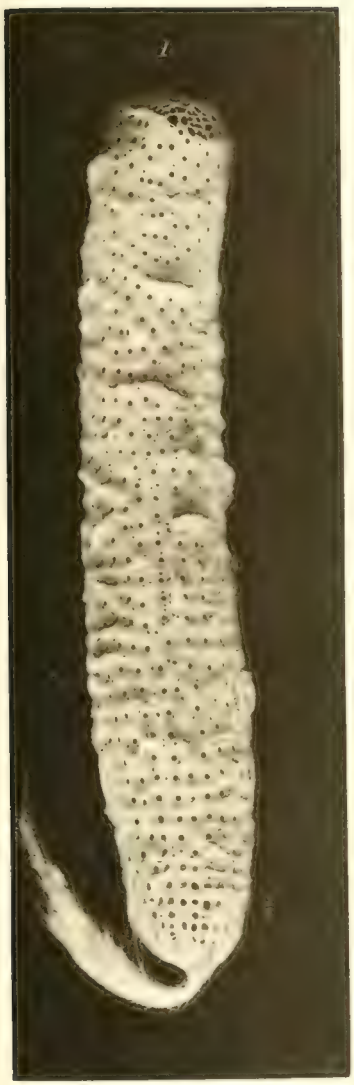
Fig. 3. Lower portion of the same specimen, seen from the broader side. $^2/_3$ nat. size.

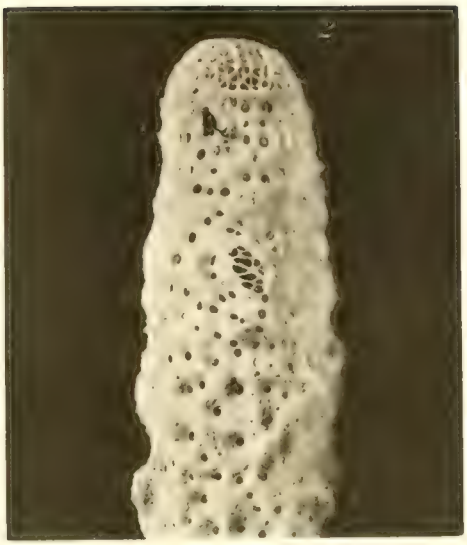
Fig. 4. A specimen (Mr. Owston's) with little ledges or none at all. $^2/_3$ nat. size.

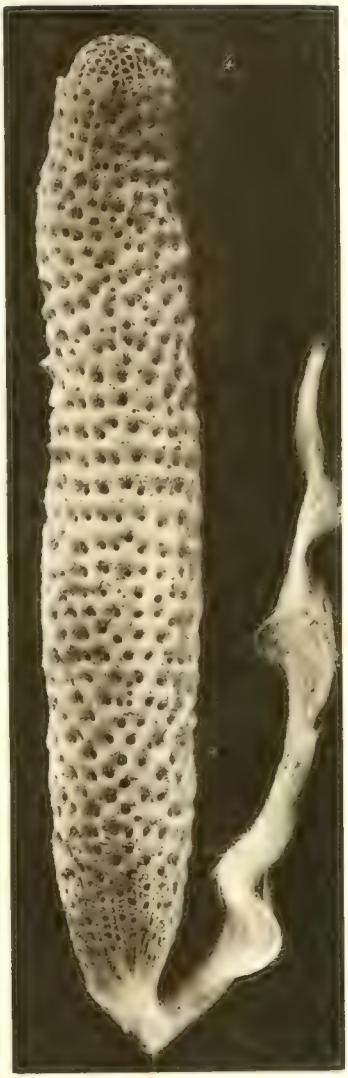
Figs. 5–6. Oxyhexasters. 440 ×.

Figs. 7–9. Anchor-heads of basal spicules. Figs. 7 & 8, abnormally developed. Fig. 9, normal. 150 ×.

Fig. 10. Oscularia in situ. To the left, edge of the oscular membrane. 100 ×.







PODICTILLA OWENI Hinde & Marrow.

PLATE VII.

Regadrella okinoseana Ij.

Plate VII.

Regadrella okinoseana Ij.

Fig. 1. A complete and well-preserved specimen in the Sci. Coll. Mus. $^1/_2$ nat. size.

Fig. 2. A specimen without the upper end, bisected and seen from the gastral side. $^2/_3$ nat. size.

Fig. 3. Dead skeleton consisting of fused spicules. $^1/_3$ nat. size.

Fig. 4. Same of small size. Nat. size.

Fig. 5. Portion of a dead skeleton, with 3 very young specimens of the same species attached to it. $1^1/_2\times$.

Figs. 6, 7. Two young specimens with still simple terminal osculum and with parietal oscula beginning to open through. Nat. size.

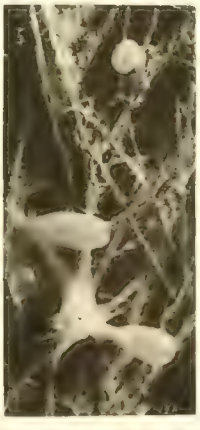
Fig. 8. Pentactin-dermalia from a very young specimen, such as one of those shown in fig. 5. 150×.

Fig. 9. Immature floricome from a young specimen. 300 ×.

Fig. 10. Surface view of dermal layer from a very young specimen, consisting of pentactin-dermalia. Here and there, rhaphidial sheaves. 50 ×.

Fig. 11. Spiculation as seen in cross-section of the wall of a very young specimen with pentactin-dermalia. Above, the dermal surface; graphiocomes, sheaves of rhaphides, &c. 50 ×.

Fig. 12. Spiculation of the wall (peripheral portion only) of a small specimen, in which hexactin-dermalia have been added in large numbers to pentactin-dermalia of an earlier developmental stage. 50×.



REGADRELLA OKINOSEANA Ij.

PLATE VIII.

Regadrella okinoseana Ij.

Plate VIII.

Regadrella okinoseana Ij.

Fig. 13. Large hexactin-dermalia (prostalia marginalia) from the cuff-edge. Rhaphides adhering to the distal ray. 150 ×.

Figs. 14–18. Hexactin-dermalia of various sizes from the ledge. 150 ×.

Figs. 19–20. Oxyhexasters. 300 ×.

Fig. 21. Oxystauraster seen from side. 300 ×.

Fig. 22. Same seen flat on. 300 ×.

Fig. 23. Floricome. 300 ×.

Figs. 24–26. Intermedial microxyhexactins with spinose rays. 300 ×.

Figs. 27–28. Occasional intermedial spicules (canalaria ?). 150 ×.

Fig. 29. Section of the edge of a parietal ledge. 100 ×.

Fig. 30. Trabeculæ, with thesocytes (*th.*). 440 ×.

Fig. 31. Portion of sieve-plate beam, seen from dermal side. 50 ×.

Figs. 32–36. Some spicules shaken out from the dead skeleton shown in Pl. VII, fig. 3.—Fig. 32, spinose microxyhexactin (300 ×). Fig. 33, rare form of an intermedial hexactin (basidictyonalia ?) (150 ×). Fig. 34, basidictyonal hexactin (150 ×). Fig. 35, oxystauraster (300 ×). Fig. 36, remnant of a graphiocome after loss of terminals (300 ×).

Fig. 37. Portion of oscular membrane, with spinose spicules which grade over into microxyhexactins. From a small and rather young specimen. 100 ×.

REGADRELLA OKINOSEANA Ij.

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PLATE IX.

Regadrella komeyamai Ij.

Plate IX.

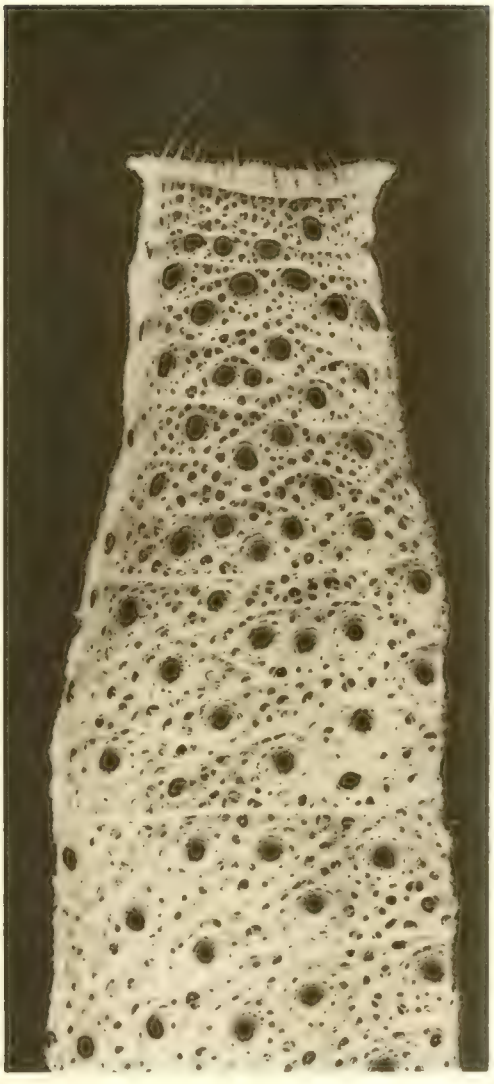
Regadrella komeyamai Iji.

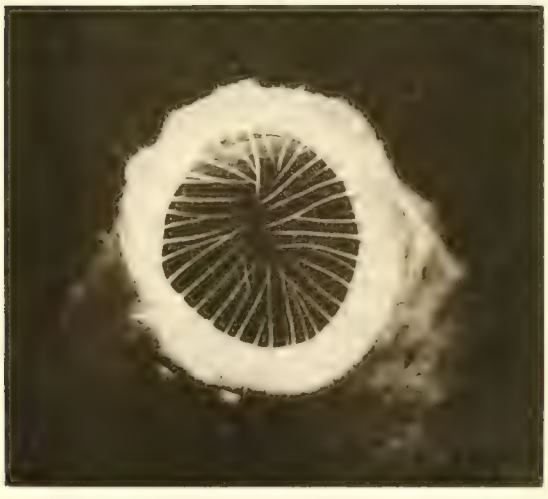
Fig. 1. The type specimen in the Sci. Coll. Mus., consisting of two individuals. $^{2}/_{5}$ nat. size.

Fig. 2. Gastral side of the wall of the larger individual shown in fig. 1. Nat. size.

Fig. 3. Cuff and corona of the same, seen from above. Nat. size.

Fig. 4. Dermal surface of the same. Magnified about $1^{1}/_{2}$ ×.





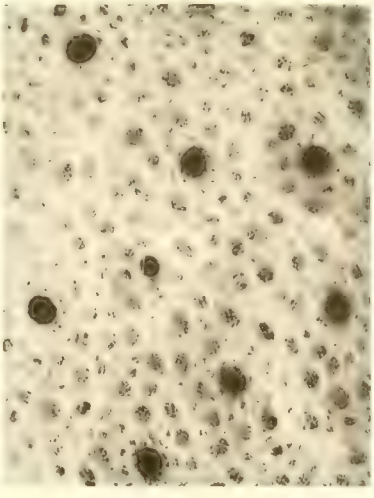


PLATE X.

Regadrella komeyamai Ij.

Regadrella phœnix O. Schm.

Plate X.

Figs. 5–17. *Regadrella komeyamai*. Ij.

Fig. 5. Portion of a floricome. 300 ×.
Fig. 6. A terminal from the same. Lateral view. 670 ×.
Fig. 7. Terminal disc of floricome, seen from top. 670 ×.
Fig. 8. Large, unequal rayed, coronal oxypentactin. 5×.
Fig. 9. Portion of the free, coronal ray of the same. 50×.
Fig. 10. Portion of the free ray of lateral prostal hexactins. 50 ×.
Fig. 11. Arrangement of prostal hexactins, dermalia, &c., at the edge of pleural prominence. 25×.
Fig. 12. Combination figure to show the spiculation of the wall. Above dermal, below gastral surface. 25×.
Fig. 13. Unusually large dermalia approaching a prostal hexactin. 150×.
Figs. 14, 15. Ordinary dermalia. 150 ×.
Fig. 16. Onychaster. 300 ×.
Fig. 17. A piece of the basal mass. Basidictyonal hexactins recognizable. 50 ×.

Figs. 18–27. *Regadrella phœnix* O. Schm.

(All figures from a specimen preserved on board the U.S. Fish-Commission Steamer 'Albatross').

Fig. 18. Portion of a floricome. 300 ×.
Fig. 19. Same. 670 ×.
Fig. 20. Onychaster. 300 ×.
Fig. 21. Terminal claws of same. 1000 ×.
Fig. 22. Combination figure to show the spiculation of the wall. Above dermal, below gastral surface. 25 ×.
Figs. 23, 24. Ordinary dermalia.
Figs. 25–27. Portions of large, sword-shaped dermalia found in groups on the lateral wall, around the hydranth of a commensal Hydrozoa. 100 ×.

5—17. REGADRELLA KOMEYAMAI Ij.

18—27? REGADRELLA PHŒNIX O. Schm.

PLATE XI.

Regadrella phœnix O. Schm.

Plate XI.

Regadrella phœnix O. Schm.

(All figures from a specimen on board the U.S. Fish-Commission Steamer 'Albatross').

Fig. 1. Upper end of the specimen, seen from above. With damaged sieve-plate. Nat. size.

Fig. 2. Upper portion of the same in lateral view. Nat. size.

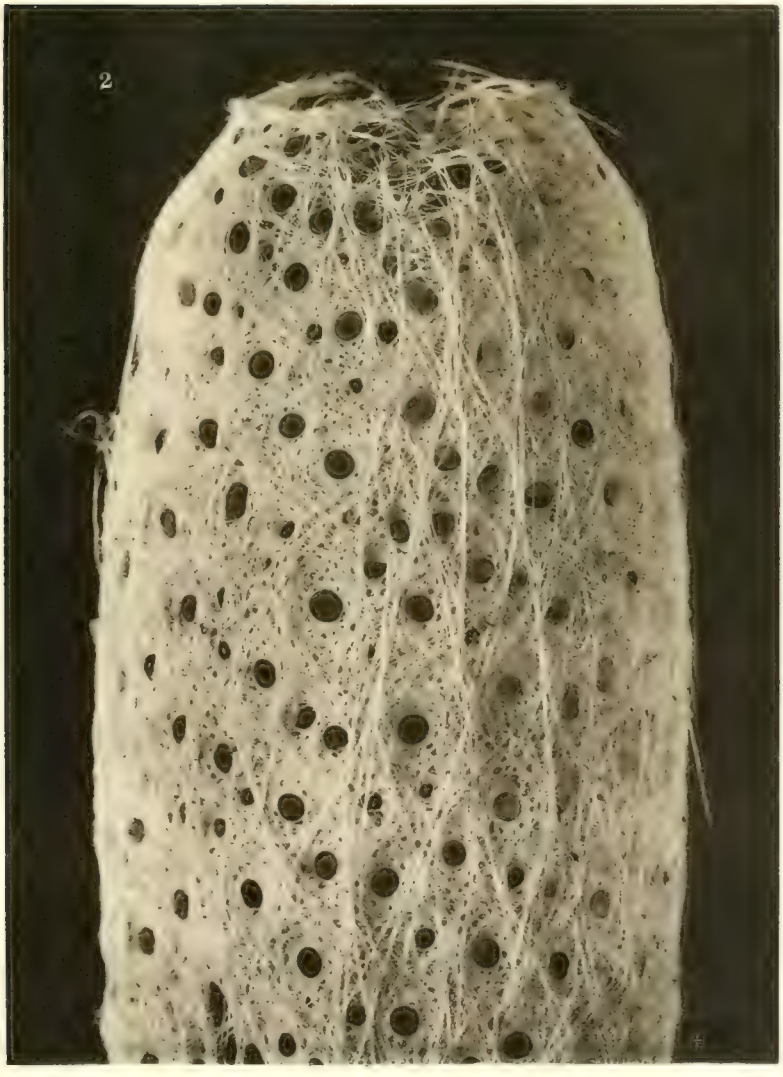
Fig. 3. Small portion of dermal surface with a remnant of extremely delicate dermal latticework and with small groups of unusually large dermalia in association with the hydranth of commensal Hydrozoa. About 10 ×.

Fig. 4. Large dermalia (prostalia marginalia) from the free edge of the obsoletely developed cuff. 100 ×.

Figs. 5, 6. Strong, unequal rayed oxystauractin and oxypentactin from the sieve-plate border, the superior ray of which gives support to radial beams of the sieve-plate. 5 ×.

Fig. 7. Small portion of the superior ray above-mentioned. 50 ×.

Fig. 8. Portion of a sieve-plate beam. 50 ×.



♀ REGADRELLA PHŒNIX O. Schm.

PLATE XII.

Walteria leuckarti Ir.

Plate XII.

Walteria leuckarti Ij.

All figures in $^1/_4$ nat. size.

Fig. 1. A well-preserved specimen which was in possession of Mr. Alan Owston. Upper end of the stem broken off.

Fig. 2. A specimen in the Sci. Coll. Mus. With all the tissues fallen off. Upper end broken.

Fig. 3. A well-preserved specimen with the apical end intact. Lower part wanting.

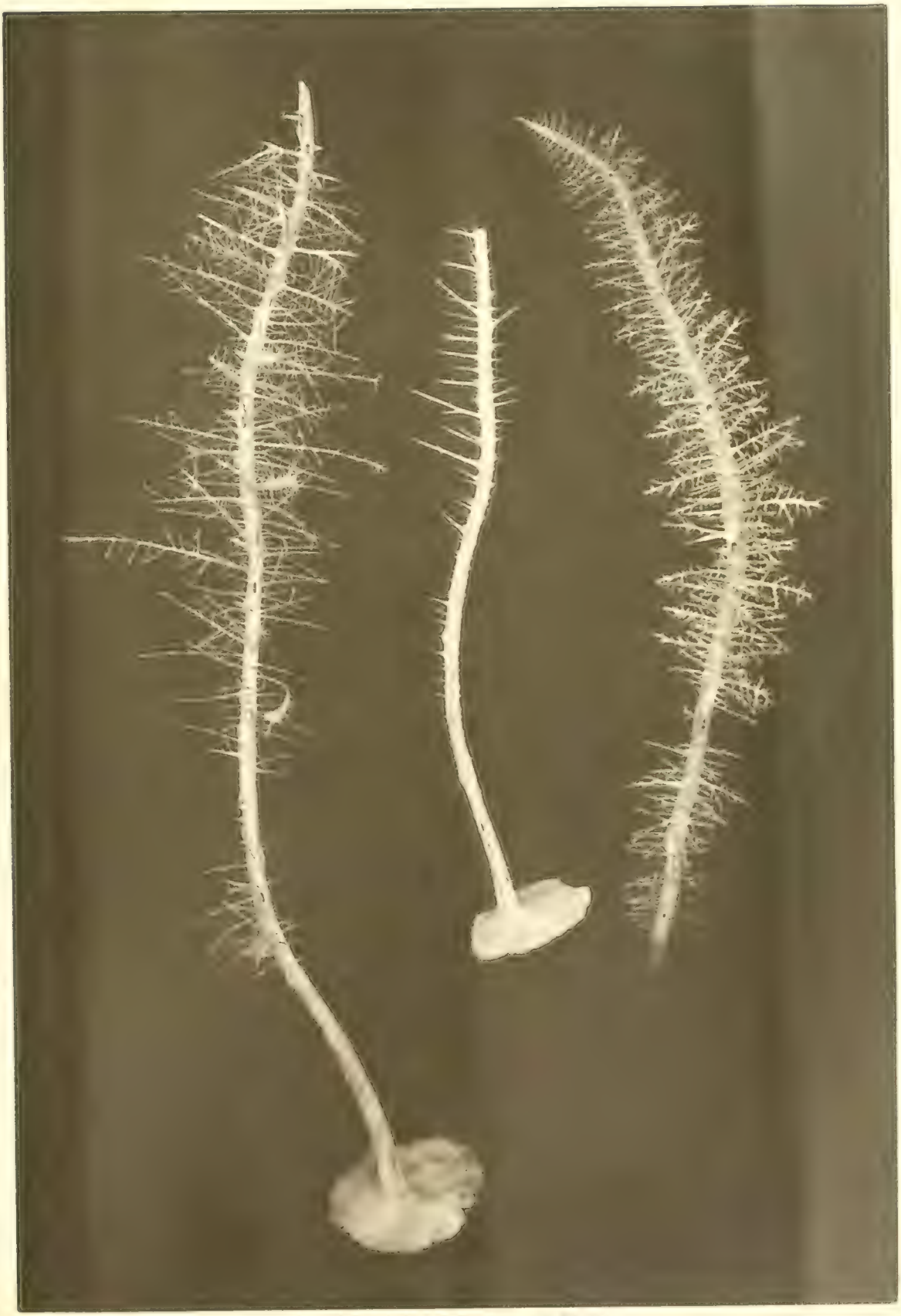


PLATE XIII.

Walteria leuckarti Ij.

Plate XIII.

Walteria leuckarti Ij.

Fig. 4. The abnormally swollen, upper end of the stem in an otherwise normally developed specimen. $^2/_3$ nat. size.

Fig. 5. A part of the stem-wall cut open so as to show the gastral surface. $^2/_3$ nat. size.

Figs. 6–9. Sword-shaped dermalia. 150 ×.

Fig. 10. Pentactin-gastralia. 150 ×.

Fig. 11. Graphiocome. 300 ×.

Fig. 12. Spherical discohexaster. 300 ×.

Fig. 13. Same, partly broken. 300 ×.

Fig. 14. Portion of a terminal of same. To the right, terminal disc as seen from top. About 1200 ×.

Fig. 15. Onychaster. 300 ×.

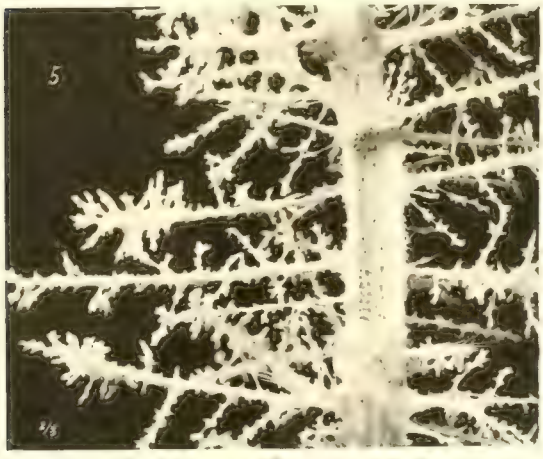
Fig. 16. Principal and terminal ray of same. About 1200 ×.

Fig. 17. Another onychaster with more number of terminals. 300 ×.

Figs. 18, 19. Spinose parenchymal oxyhexactin. 300 ×.

Fig. 20. Terminal portion of a branch, magnified about 5 ×. The numerous openings are those of cavities containing hydranths of the commensal Hydrozoa. At the lower end the cortical tissue has been stripped off, exposing the core composed of parenchymal diactins.

Fig. 21. Cortical tissue and a portion of the core of a branch in longitudinal section. About 50 ×. Above, the external surface with dermalia: below, parenchymal diactins.—*cav.hy.*, cavities containing the hydranth of the commensal Hydroza, with remnant of tissues belonging to the latter. *cœn.*, cœnosarc of the Hydrozoa.



WALTERIA LEUCKARTI H.

PLATE XIV.

Topography of the Sagami Sea.

Pl. XIV.

Chart illustrating the topography of the Sagami Sea. See pp. 6–15.

Topography of SAGAMI SEA

Compiled by Prof. I. Ijima

PROV. SAGAMI

GULF OF TŌKYŌ

SAGAMI BAY

Odawara Maye

Atami Maye

MIURA PENINSULA

CENTRAL BASIN OF THE SAGAMI SEA

Misaki Marine Laboratory

Inside Okinosé

Homba

GOKEBA BASIN

Gokeba

PROV. IZU

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PROV. AWA

Soundings in fathoms, taken from Hydrographic Charts of I. J. Navy.

fathoms line

Scale in kilometres

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